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Draft A

Limited Field Investigation Report for the 100-FR-1 Operable Unit

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EXECUTIVE SUMMARY

BACKGROUND

This limited field investigation (LFI) report summarizes the data collection and analysis activities conducted during the 100-FR-1 Source Operable Unit LFI and the associated qualitative risk assessment (QRA), and makes recommendations on the continued candidacy of high-priority sites for interim remedial measures (IRM). The results and recommendations presented in this report are generally independent of future land use scenarios. This report is unique in that it is based on Hanford-specific agreements discussed in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990), the *Hanford Site Risk Assessment Methodology* (DOE-RL 1994a), the *RCRA Remedial Investigation/Feasibility Study Work Plan for the 100-FR-1 Operable Unit* (DOE-RL 1992a), and the *Hanford Past-Practice Strategy* (HPPS) (DOE-RL 1991), and must be viewed in this context. The HPPS, described and justified in *The Hanford Federal Facility Agreement and Consent Order Change Package* (Ecology et al. 1991), emphasizes initiating and completing waste site cleanup through interim actions.

An LFI is required when existing data are insufficient to formulate a conceptual model and perform a QRA. The purpose of the report is to identify those sites that are recommended to remain as candidates for IRM, provide a preliminary summary of site characterization studies, refine the conceptual model as needed, identify contaminant- and location-specific applicable or relevant and appropriate requirements (ARAR), and provide a qualitative assessment of the risks associated with the sites. This assessment includes consideration of whether contaminant concentrations pose an unacceptable risk that warrants action through IRM. An IRM is defined by the HPPS in broad terms and is not restricted to limited- or near-term actions. Interim remedial measures are intended to achieve remedies that are likely to lead to a final Record of Decision. The final decision to conduct an IRM will rely on many factors including risk, ARAR, future land use, point of compliance, time of compliance, a bias-for-action, and the threat to human health and the environment.

The unit managers assigned all known and suspected areas of contamination in the 100-FR-1 Operable Unit either a high- or low-priority, as listed in Table ES-1. The classification of sites was based on the collective knowledge of the three parties and information contained in existing work plans. The site classification decisions were made during joint meetings with the three parties and are documented by meeting minutes that are part of the administrative record. Sites classified as high-priority were judged to pose risk(s) through one or more pathways sufficient to recommend a streamlined action via an IRM. Low-priority sites do not pose risks sufficient to recommend streamlining.

The 100-FR-1 Operable Unit is one of three operable units associated with the 100 FR Area at the Hanford Site. The 100-FR-1 and 100-FR-2 Operable Units address contaminant sources while the 100-FR-3 Operable Unit addresses contamination present in the underlying groundwater. The 100-FR-1 Operable Unit encompasses approximately 1.3 km^2 (0.5 mi^2) and is located immediately adjacent to the Columbia River shoreline. In general, it contains waste units associated with the original plant facilities constructed to support F Reactor operation, as well as the cooling water retention basin system and biological laboratories for studying the effects of radiation on plants and animals.

The 100-FR-1 LFI began the investigative phase of the remedial investigation for a select number of high-priority sites. The LFI was performed to provide additional data needed to support selection, design and implementation of IRM, if needed. The LFI included: data compilation, nonintrusive investigations, intrusive investigations at eight high-priority sites, summarization of 100 Area aggregate studies, and data evaluation.

INVESTIGATION RESULTS

Three methods of intrusive investigation were used in the LFI: boreholes were drilled, test pits were excavated, and surface soils were sampled. The samples were submitted for laboratory analysis. One remote sensing technique was employed to radiologically survey boreholes using downhole geophysical techniques to further delineate the locations and levels of radiological contaminants. Materials removed from the boreholes and test pits were screened in the field for volatile organic compounds and radionuclides to assist in selection of sample intervals. Analytical data were validated. All data associated with the LFI were evaluated.

Eight high-priority sites were intrusively investigated: 116-F-1, 116-F-2, 116-F-3, 116-F-4, 116-F-6, 116-F-9, 116-F-14, and the 108-F french drain. One low-priority site (132-F-1) was intrusively investigated because it was associated with the experimental animal farm and is unique to the 100-FR-1 Operable Unit. Boreholes were drilled and sediments sampled at 116-F-1, 116-F-2, 116-F-4, 116-F-6, 116-F-9, and 116-F-14. Test pits were excavated and sediments sampled at 116-F-1, 116-F-3, 116-F-9, and 132-F-1 (low-priority site). Surface sediments were sampled at the 108-F french drain.

Radiological contamination is the primary concern as confirmed through this study. The principal radionuclides of concern are potassium-40, cobalt-60, strontium-90, cesium-137, europium-152, europium-154, radium-226, thorium-228, and plutonium-238. The highest concentrations of radionuclides were found in 116-F-4 pluto crib and the 116-F-14 retention basin samples. No Concentrations exceed potential soil ARAR, Model Toxics Control Act (MTCA) Method B concentrations. Semi-volatile organic compounds were detected in low concentrations, and were generally below the contract required quantitation limits. Volatile organic compounds, while detected, were generally low in concentration or likely are laboratory artifacts. Contaminant concentrations and locations determined through the intrusive investigation generally confirm historical information such as documented in Dorian and Richards (1978). The remaining high-priority sites in the 100-FR-1 Operable Unit were evaluated using data from analogous facilities in the 100 Areas. An expedited response action is not warranted based on the evidence of this investigation.

QUALITATIVE RISK ASSESSMENT

A QRA was performed for the high-priority sites. Conservative assumptions such as highest reported contaminant levels from either the LFI or historical data base were utilized. The QRA provides estimates of human health risks assuming either frequent- or occasional-use and includes considerations such as the attenuation of external dose provided by layers of clean gravel fill that overlie many sites. The QRA identifies the human health risk to be external exposure from the radionuclides cobalt-60, cesium-137, europium-152, and europium-154. The QRA also provides environmental hazard quotient (EHQ) risk estimates for the 100-FR-1 high-priority sites.

SITE EVALUATION CRITERIA

The 100-FR-1 high-priority sites were evaluated using the following criteria to identify and screen sites recommended to continue as an IRM candidates; a detailed discussion of the criteria is provided in Section 5.2 of this report:

- The QRA provides risk estimates for human health and the EHQ ratings. Sites with high or medium risks to human health for the occasional-use scenario are recommended to continue as IRM candidates. High risk corresponds to an incremental cancer risk (ICR) >1E-02. Medium risk corresponds to an ICR between 1E-04 and 1E-02. Low risk corresponds to an ICR between 1E-06 and 1E-04. Very low risk corresponds to an ICR of <1E-06. Sites with an EHQ rating >1 are also recommended to continue as IRM candidates.

- If contamination at the waste site exceed a chemical-specific ARAR, that site is recommended to continue as an IRM candidate. The Washington State MTCA Method B concentrations are potential ARAR for soil contamination, as discussed in Section 3-20 of this report and in the *100 Area Feasibility Study, Phases 1 and 2* (DOE-RL 1992c). Model Toxics Control Act Method B for soil contaminant concentrations are utilized because they are the accepted regulatory guideline.

- If LFI results indicate that a site is a current source of groundwater contamination then the site is recommended to continue as an IRM candidate.

- The conceptual model for the waste site includes sources of contamination, types of contaminants, affected media, known and potential routes of migration, known or potential human and environmental receptors, and the general understanding of the site structure/process. If the conceptual model of the site is found to be incomplete, collection of data needed to complete the model through limited field sampling is recommended. Sites with incomplete conceptual models are recommended to continue as IRM candidates.

- The potential for the contaminants at a site to be reduced by natural attenuation, e.g., radioactive decay by the year 2018, may be a consideration for sites where the excess risk is caused by external exposure from radionuclides with half lives of <30 years. This is not a consideration for sites where multiple exposure pathways drive the risk.

IRM RECOMMENDATIONS

Table ES-2 presents the evaluation of the high-priority waste sites using the above criteria, and the site-specific IRM candidate recommendations. The following sites are recommended to continue as IRM candidates:

- 116-F-1, 116-F-2, 116-F-3, 116-F-6, 116-F-9, 116-F-10, 116-F-14, and 108-F french drain.

- These additional sites are recommended to continue as IRM candidates. 116-F-8, 116-F-12, 116-F-13, UN-100-F-1, 132-F-6, and the Pacific Northwest Laboratory outfall structure. Additional limited sampling is recommended at these sites in order to complete their conceptual models. Once the conceptual models are completed the sites should be reevaluated to consider their continued candidacy for IRM.

The 116-F-4, 116-F-5, 116-F-11, and the Process/Discharge Pipelines are not recommended to continue as IRM candidates because human and ecological risks are low, soil contamination does not exceed ARAR, there is no impact to groundwater, and natural attenuation will further reduce site risks. Action at these sites may be deferred until final remedy selection.

Table ES-1 100-FR-1 Operable Unit High-Priority Sites and Low-Priority Facilities

High-Priority Sites	Low-Priority Sites
116-F-1 Trench *	116-F-7 French Drain +
116-F-2 Trench *+	1607-F Septic tanks and Drain Fields +
116-F-3 Storage Basin Trench *+	132-F-1 Chronic Feeding Barn *
116-F-4 Crib *	132-F-3 Gas recirculation Facility demolition Site +
116-F-5 Crib	132-F-5 Filter Facility Demolition Site +
116-F-6 Liquid Waste Disposal Trench *	
116-F-8 Outfall Structure +	
116-F-9 Trench *	
116-F-10 French Drain	
116-F-11 French Drain	
116-F-12 French Drain	
116-F-13 French Drain	
116-F-14 Retention Basins *+	
108-F French Drain *	
Process/Discharge Pipelines	
UN-100-F-1 Spill	
132-F-6 Waste Water Pumping Station	
PNL Outfall Structure	

* = Additional sampling conducted as part of a limited field investigation
+ = Additional data from an analogous facility (DOE-RL 1992a)
PNL = Pacific Northwest Laboratory

Table ES-2 IRM Recommendations for 100-FR-1 High-Priority Sites

Waste Site	Qualitative Risk Estimation		Conceptual Model	Exceeds ARAR	Possible Current Impact on Groundwater	Potential for Natural Attenuation by 2018	IRM Candidate yes/no
	Occasional-Use Scenario	EHQ > 1					
116-F-1 Lewis Canal	Medium	Yes	Adequate	No	Unknown	No	Yes
116-F-2 Basin Overflow Trench	Medium	Yes	Adequate	No	Unknown	No	Yes
116-F-3 Fuel Storage Basin Trench	Medium	Yes	Adequate	No	Unknown	No	Yes
116-F-4 Pluto Crib **	Medium**	Yes**	Adequate	NA	Unknown	NA	No **
116-F-6 Liquid Waste Disposal Trench	Medium	Yes	Adequate	No	No	No	Yes
116-F-9 PNL Animal Waste Leach Trench	Low	Yes	Adequate	No	No	No	Yes
116-F-14 Retention Basin	Medium	Yes	Adequate	No	Yes	No	Yes
108-F French Drain	Low	Yes	Adequate	No	Yes	No	Yes
116-F-5 Ball Washer Crib	Very Low	No	Adequate	Unknown	No	Yes	No
116-F-8 Outfall Structure	Medium*	--	Incomplete*	Unknown*	Unknown*	Unknown*	Yes*
116-F-10 Dummy Decontamination French Drain	Medium	No	Adequate	Unknown	No	Yes	Yes
116-F-11 Cushion Corridor French Drain	Low	No	Adequate	Unknown	Unknown	Yes	No
116-F-12 French Drain	Medium*	--	Incomplete*	Unknown*	No	Unknown*	Yes*
116-F-13 Experimental Garden French Drain	Medium*	--	Incomplete*	Unknown*	No	Unknown*	Yes*
Process/Discharge Pipelines	Very Low	No	Adequate	Unknown	Unknown	Yes	No
UN-100-F-1	Low*	--	Incomplete*	Unknown*	No	Unknown*	Yes*
132-F-6 Lift Station Demolition Site	Very Low*	--	Incomplete*	Unknown*	Unknown*	Unknown*	Yes*
PNL Outfall Structure	Low*	--	Incomplete*	Unknown*	Unknown*	Unknown*	Yes*

* = Not sampled, conceptual model is considered incomplete, risk is based upon analogous information
** = Qualitative risk reduced/removed by removal of contaminated material as part of the 100 Area Excavation Treatability Test (DOE-RL 1994b) (Qualitative Risk Estimation based upon LFI Borehole Data prior to Treatability Excavation)
-- = Not rated by the qualitative ecological risk assessment
ARAR = Applicable or Relevant and Appropriate Regulation, specifically the Washington state Model Toxics Control Act Method B concentration values for soils (DOE-RL 1992a)
EHQ = Environmental Hazard Quotient calculated by the qualitative ecological risk assessment (WHC 1993)
NA = Not Applicable
Shaded areas indicate driving factors keeping site as IRM candidate

ACRONYMS

ARAR	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
COPC	contaminants of potential concern
CRQL	contract required quantitation limit
DOE	U.S. Department of Energy
EAF	Experimental Animal Farm
Ecology	Washington State Department of Ecology
EHQ	environmental hazard quotient
EII	Environmental Investigation Instruction
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
FS	feasibility study
HPPS	Hanford Past-Practice Strategy
ICR	incremental cancer risk
IRM	interim remedial measure
LFI	limited field investigation
MTCA	Model Toxics Control Act
NCRP	National Council on Radiation Protection and Measurements
OVM	organic vapor monitor
PCB	polychlorinated biphenyl
PID	photoionization detector
PNL	Pacific Northwest Laboratory
QC	quality control
QRA	qualitative risk assessment
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RL	Richland Operations Office
sG	specific gravity
TAL	target analyte list
TBC	to-be-considered
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
UTL	upper threshold limit
VOC	volatile organic compound
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

This report summarizes the data collection and analysis activities during the 100-FR-1 Operable Unit limited field investigations (LFI) as well as the results of the associated qualitative risk assessment (QRA). The *Hanford Past-Practice Strategy* (HPPS) (DOE-RL 1991), described in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Change Package (Ecology et al. 1991), emphasizes accelerated cleanup of waste-sites. This accelerated cleanup is done through a process called interim remedial measures (IRM). A LFI is required when waste sites are to be considered for IRM and existing data are insufficient to formulate a conceptual model and perform a QRA. The information gathered during the LFI activities is then used to aid in making decisions regarding performing IRM. The objectives of the LFI are described fully in the *RCRA Remedial Investigation/Feasibility Study Work Plan for the 100-FR-1 Operable Unit* (DOE-RL 1992a), also referred to as the 100-FR-1 Operable Unit Work Plan. Objectives are:

- identify those high-priority sites that are recommended to remain as candidates for IRM
- summarize data collection and analysis activities
- refine the conceptual model as needed
- provide a qualitative assessment of the risks associated with the sites.

To limit the size of this report, the reader is referred to other documents for specific details. This LFI report is based on agreements discussed in these Hanford Site specific documents:

- *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990)
- *Hanford Past-Practice Strategy* (DOE-RL 1991)
- *Hanford Site Risk Assessment Methodology* (DOE-RL 1994a)
- *RCRA Remedial Investigation/Feasibility Study Work Plan for the 100-FR-1 Operable Unit* (DOE-RL 1992a).

It is important to note that the methods and requirement for completing IRM, QRA, and LFI reports are specific to the Hanford Site and may differ from activities with similar names performed elsewhere. The methods and requirements used at the Hanford Site were agreed to by the signatories of the Tri-Party Agreement.

Before LFI work began, the operable unit managers assigned either a high- or low-priority to all known and suspected areas of contamination in the 100-FR-1 Operable Unit. Table 1-1 lists these sites and Figure 1-1 shows site locations. The classification of sites was based on information from the work plans, historical information, and the collective knowledge from Westinghouse Hanford Company (WHC) and its subcontractors, U.S. Department of Energy - Richland Operations Office (DOE-RL), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology). The prioritization decisions were made during joint meetings with all the parties and are documented in meeting minutes that are part of the Administrative Record for the 100-FR-1 Operable Unit. Eighteen sites were classified as high-priority, they pose potential risk(s) through one or more pathways sufficient to recommend cleanup via an IRM. Five low-priority sites were identified which do not pose potential risks sufficient to justify streamlining. The parties agreed that:

- none of the high-priority sites pose potential risks that would require an expedited response action (ERA)
- LFI sampling was needed at 8 of 18 high-priority sites where data were deemed insufficient to formulate a conceptual model and support the QRA
- certain activities would be more efficient to implement at the 100 Area aggregate or Hanford Site scale rather than the operable unit scale.

This LFI report refines the conceptual model (a description of the contaminants and their pathways to humans and the environment) and identifies other potential regulations affecting cleanup (applicable or relevant and appropriate requirements [ARAR]). The QRA (summarized within the LFI report) uses both historical and the LFI data to show if contaminants pose an unacceptable risk that warrants continuing a site on the IRM path. The QRA is used only to assess risk for an IRM determination and is not intended to define current risk or baseline risk in a traditional sense.

1.1 SITE BACKGROUND

The 100 F Area is located in the north-central part of the Hanford Site along the southern shoreline of the Columbia River, approximately 32 km (20 mi) northwest of the City of Richland, in the south-central portion of Washington State (DOE-RL 1992a).

1.1.1 Operable Unit Background

The 100-FR-1 Operable Unit comprises the northern half of the 100 F Area and is located immediately adjacent to the Columbia River shoreline, encompassing approximately 1.3 km^2 (0.5mi^2) (See Figure 1-2 for location). It lies predominately within Section 33, the eastern portion of Section 32, and the southeastern portion of Section 29 of Township 14N, Range 27E. It is bounded by north/south Hanford Site plant coordinates N78500 and N82500 and east/west coordinates W27600 and W33000 (DOE-RL 1992a).

The 100-FR-1 Operable Unit is one of three operable units associated with the 100 F Area at the Hanford Site (see Figure 1-3). The 100-FR-1 and 100-FR-2 are source operable units, that address liquid effluent disposal sites, solid waste burial grounds, and their underlying vadose zone. The 100-FR-1 Operable Unit contains waste units associated with the original plant facilities constructed to support F Reactor operations, cooling water retention basin systems and biological laboratories used for studying the effects of radiation on plants and animals. The 100-FR-3 Groundwater Operable Unit addresses contamination that has migrated to the underlying groundwater.

The 100 F Reactor was the third Hanford reactor built to manufacture plutonium during World War II. Fuel elements for the reactor were assembled in the 300 Area, and the plutonium-enriched fuel produced by the reactor was processed in the 200 Area. The 100 F Reactor operated from 1945 to 1965, when it was retired. After the reactor was retired, the buildings and facilities began decontamination and decommissioning to minimize the potential spread of radioactive isotopes. The process is ongoing, although most of the structures in the 100 F Area have been demolished.

Adjacent to the 100 F Reactor site was the Experimental Animal Farm (EAF), which operated from 1945 until 1976. Deford (1993) provides a summary of EAF facilities and their operational histories. This section summarizes that data.

The main biology laboratory for studying the effects of radiation on animals and plant life was the 108-F building, which contained offices and laboratories. The earliest animal research at 100 F began in 1945. These studies involved exposing fish to varying concentrations of reactor cooling water effluent to assess possible effects of effluent discharge on aquatic life in the Columbia River. Studies involving sheep began in the late 1940s and studies involving swine began in 1952. Most of the work performed on these animals involved 20-year lifetime exposure studies. At various times, pilot studies were performed using milk cows, chickens, ducks, and miniature goats. A series of studies on the effects of ionizing radiation on beagle dogs also took place.

Radioecology experiments were also conducted at the EAF. Greenhouses were used for growing potted plants. Also, strontium garden plots were used for growing cereal grains, alfalfa, and other crops in soil containing controlled amounts of strontium-90 and cesium-137.

1.1.2 The 100-FR-1 Operable Unit Conceptual Site Model

The conceptual site model for the 100-FR-1 operable unit was developed during the preparation of the remedial investigations/feasibility study (RI/FS) work plan. The conceptual model as presented in the work plan addressed the following:

- structure and process of the waste sites
- source of contaminants
- type of contaminants
- nature and potential routes or migration
- known and potential human and environmental receptors.

The conceptual model has been updated with data acquired through the LFI, and is presented in Chapter 5 of this report.

1.2 THE HANFORD PAST-PRACTICE STRATEGY AND THE 100-FR-1 LFI

1.2.1 Hanford Past-Practice Strategy

The signatories to the Tri-Party Agreement (Ecology et al. 1990) recognized the need for a new strategy of Resource Conservation and Recovery Act/Comprehensive Environmental Response Compensation and Liability Act (RCRA/CERCLA) integration to provide greater uniformity in the applicability of requirements to the Hanford Site. Additionally, the signatories agreed that proceeding with the traditional CERCLA approach would likely require too much time and too large a portion of a limited budget be spent before actual cleanup would occur. Another motivation for a new strategy was the need to coordinate past-practice investigations with RCRA closure activities since some operable units contain RCRA treatment storage and disposal facilities.

In response to the above concerns, the three parties have decided to manage and implement all past-practice investigations under one characterization and remediation strategy, regardless of the regulatory agency lead (as defined in the Tri-Party Agreement). The HPPS (DOE-Rl 1991) was developed to expedite cleanup by initiating and completing waste site cleanup through interim actions. The HPPS focuses on reaching early decisions by maximizing the use of existing data consistent with the data quality objectives with short-time-frame investigations, where necessary. As more data become available on contamination problems and associated risk, the details for longer-term investigations and studies are better defined.

The HPPS process (Figure 1-3) includes three paths for interim decision-making and a final remedy-selection process for the operable unit that incorporates the three paths and integrates sites not addressed in those paths. An important element of this strategy is the application of the observational approach, in which characterization data are collected concurrently with cleanup (DOE-RL 1991).

As shown in Figure 1-3, the three paths for interim decision-making are:

- The ERA path - used when an existing or near-term unacceptable health or environmental risk from a site is determined or suspected, and a rapid response is necessary to mitigate the problem.

- The IRM path without an LFI - used when existing data are sufficient to formulate a conceptual model and perform a QRA. If a determination is made that an IRM is justified, the process will proceed to select an IRM remedy. If necessary, a focused FS will be conducted to select a remedy.

- The LFI path - used to identify and gather the minimum additional data needed to formulate a conceptual model and perform a QRA. This information is then used to aid in decisions regarding performing ERA or IRM.

Although interim actions (ERA and IRM) may be used to mitigate specific contamination problems, the process of final remedy selection must be completed for the operable unit and 100 Area National Priority List CERCLA site to reach closure. The information obtained from the LFI and interim actions may be sufficient to perform the baseline risk assessment, and to select the remedy for the operable unit. If the data are not sufficient, additional investigations and studies will be performed to the extent necessary to support the operable unit remedy selection. These investigations would be performed within the framework and process defined for RI/FS programs.

1.2.2 Application of the Hanford Past-Practice Strategy to the 100-FR-1 Operable Unit

Implementation of the HPPS to the 100-FR-1 Operable Unit began with the development of the *RCRA Remedial Investigation/Feasibility Study Work Plan for the 100-FR-1 Operable Unit* (DOE-RL 1992a). Following agreement on the past-practice strategy, the three parties rescoped the initial 100 Area work plans with a bias toward interim remedial action (Ecology et al 1991). The collective knowledge and judgment of the three parties and the information contained in the existing work plans were used to identify the highest-priority waste sites in the 100-FR-1 Operable Unit and the paths to be followed to implement the HPPS. The decisions made during joint meetings among the three parties are documented by meeting minutes that are part of the administrative record.

The highest priority waste sites in the 100-FR-1 operable unit are identified in Table 1-1. Limited field investigations were proposed for the following high-priority sites:

- 116-F-1 trench
- 116-F-2 trench
- 116-F-3 storage basin trench
- 116-F-4 crib
- 116-F-6 liquid waste disposal trench
- 116-F-9 trench
- 108-F french drain
- 116-F-14 retention basins.

Information gained from analogous sites was also used to make recommendations on the continued IRM candidacy of high-priority waste facilities in the 100-FR-1 Operable Unit, where applicable. The knowledge gained from the characterization/remediation of other 100 Areas analogous facilities will be applied toward the remediation of these high-priority sites in the 100-FR-1 Operable Unit. At these sites, further characterization will be performed concurrently with remediation, using the observational approach.

1.3 HISTORICAL DATA

An integral part of the RCRA facility investigation/corrective measures study process for the 100-FR-1 Operable Unit has been the acquisition, evaluation, and utilization of records pertaining to the construction, operation and decontamination/ decommissioning of the reactor and related 100 F facilities. This information is categorized as "historical information," and includes operations records and reports, engineering drawings, photographs, interviews with former or retired operations personnel, and data from sampling and analysis of facilities and the local environment.

A primary reference for radiological characterization of the 100-FR-1 Operable Unit sources is a study of the 100 Areas performed during 1975/1976 by Dorian and Richards (1978). In the 100-FR-1 Operable Unit, Dorian and Richards (1978) collected samples from the retention basins, liquid waste disposal trenches, outfall structures, and the miscellaneous trenches, cribs, and french drains located near the F Reactor. The samples were analyzed for radionuclides. Inventories of radionuclides for the facilities and sites were calculated. Results from Dorian and Richards (1978) were a major resource used in the development of the 100-FR-1 conceptual model and LFI needs. It should be noted, however, that only concentrations and inventories of selected radionuclides were reported in the study. In particular, nickel-63, which is generally present at activities on the same order of magnitude as cobalt-60, was not routinely reported for many sample locations and daughter product radionuclides of strontium-90 and cesium-137, which have approximately the same activities as the parent nuclides, were not included in summaries of total activity (DOE-RL 1992a).

Figure 1-1 High-Priority Sites and Low-Priority Facility Locations

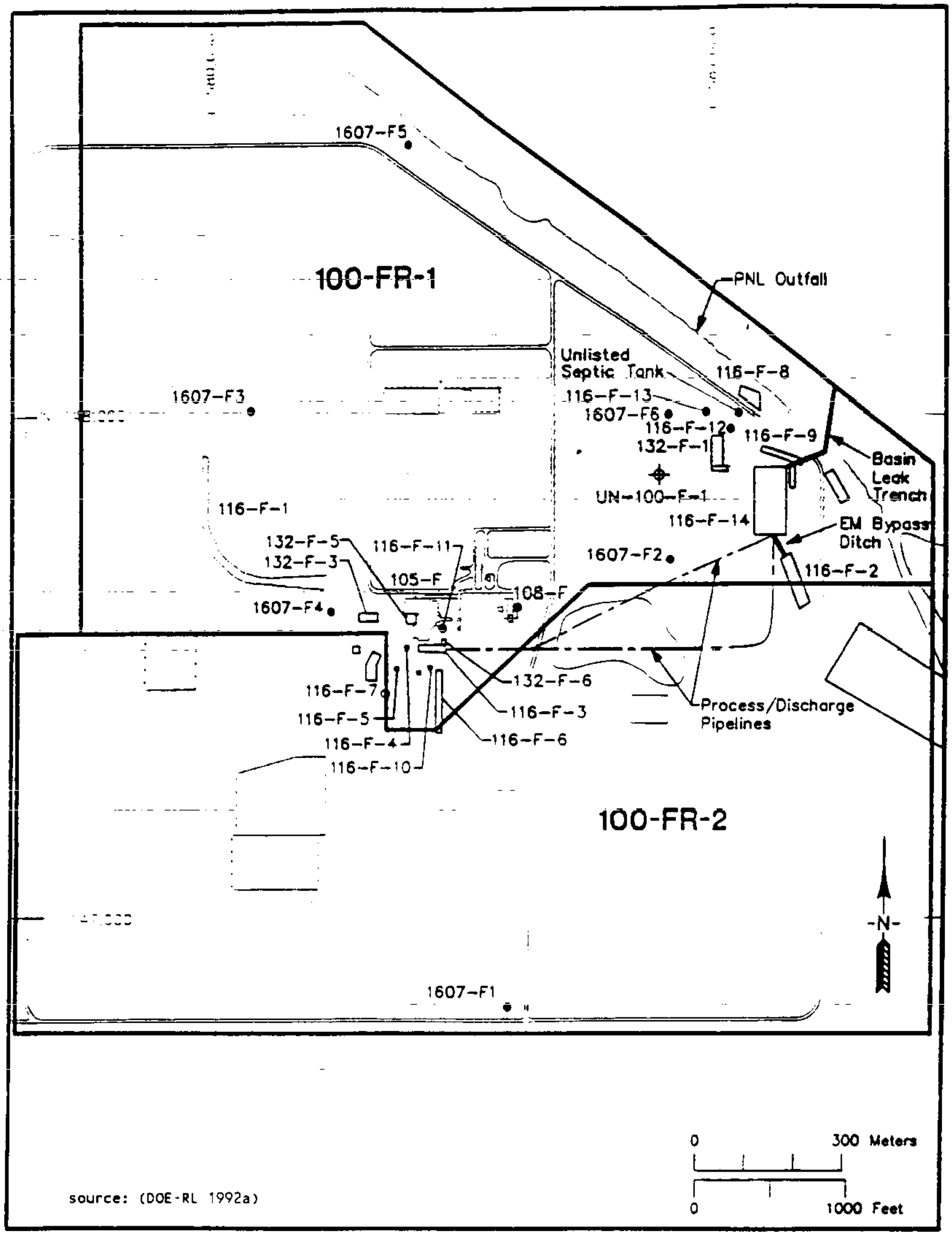

Figure 1-2 100-FR-1 Operable Unit

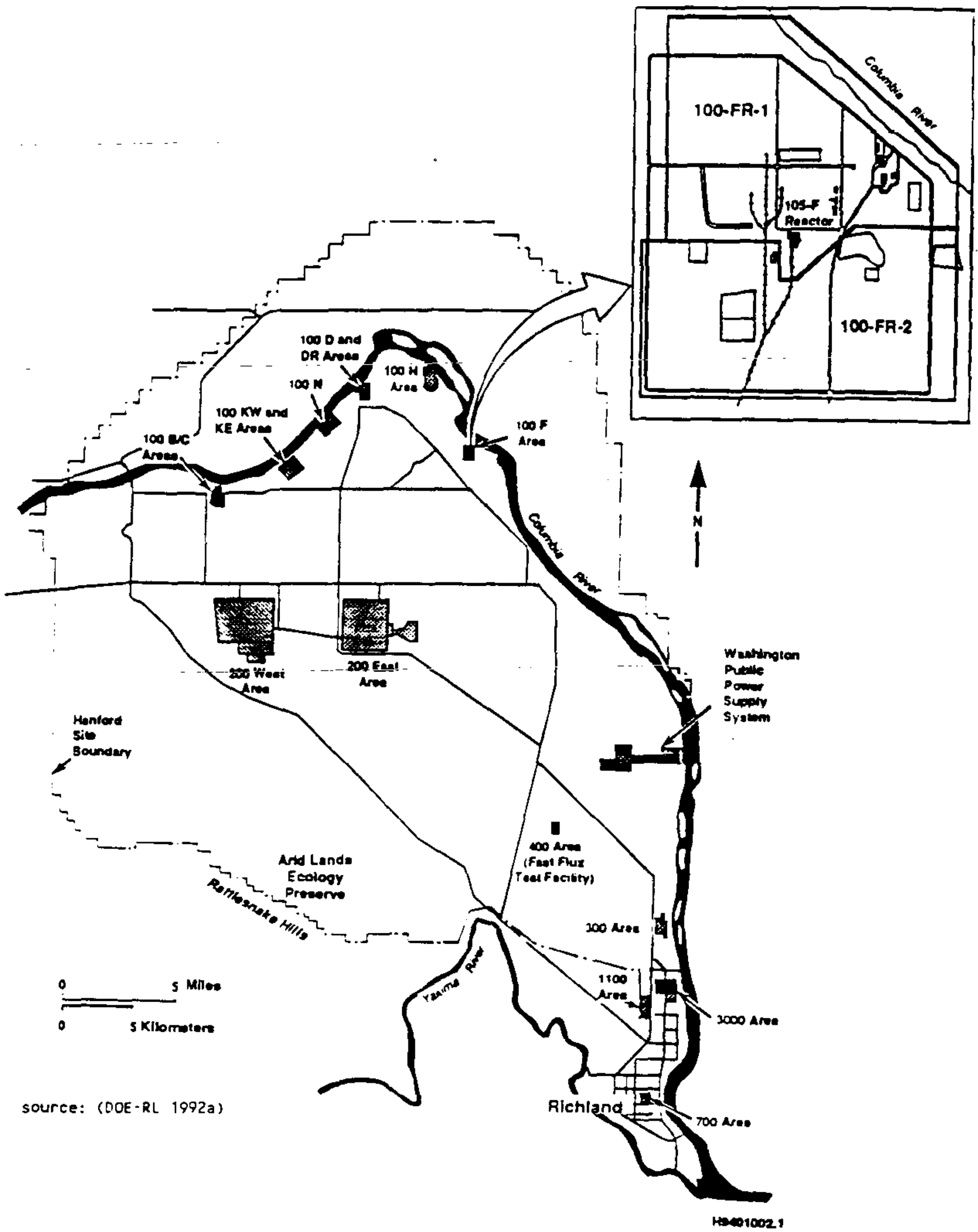

Figure 1-3 Hanford Past-Practice Strategy Decision Flow Chart

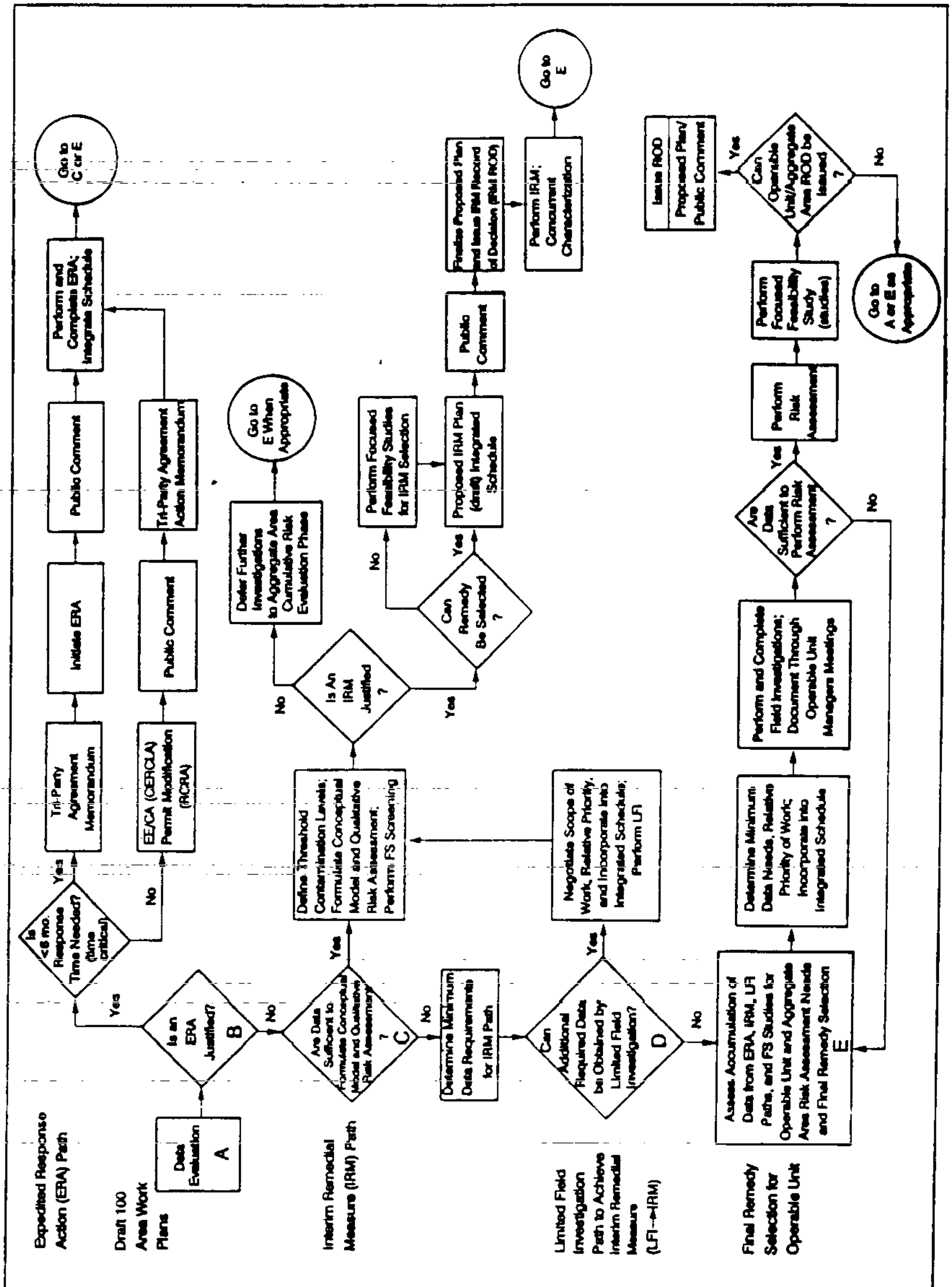

Figure 1-4 Map of 100 F Area Showing Source and Groundwater Operable Units

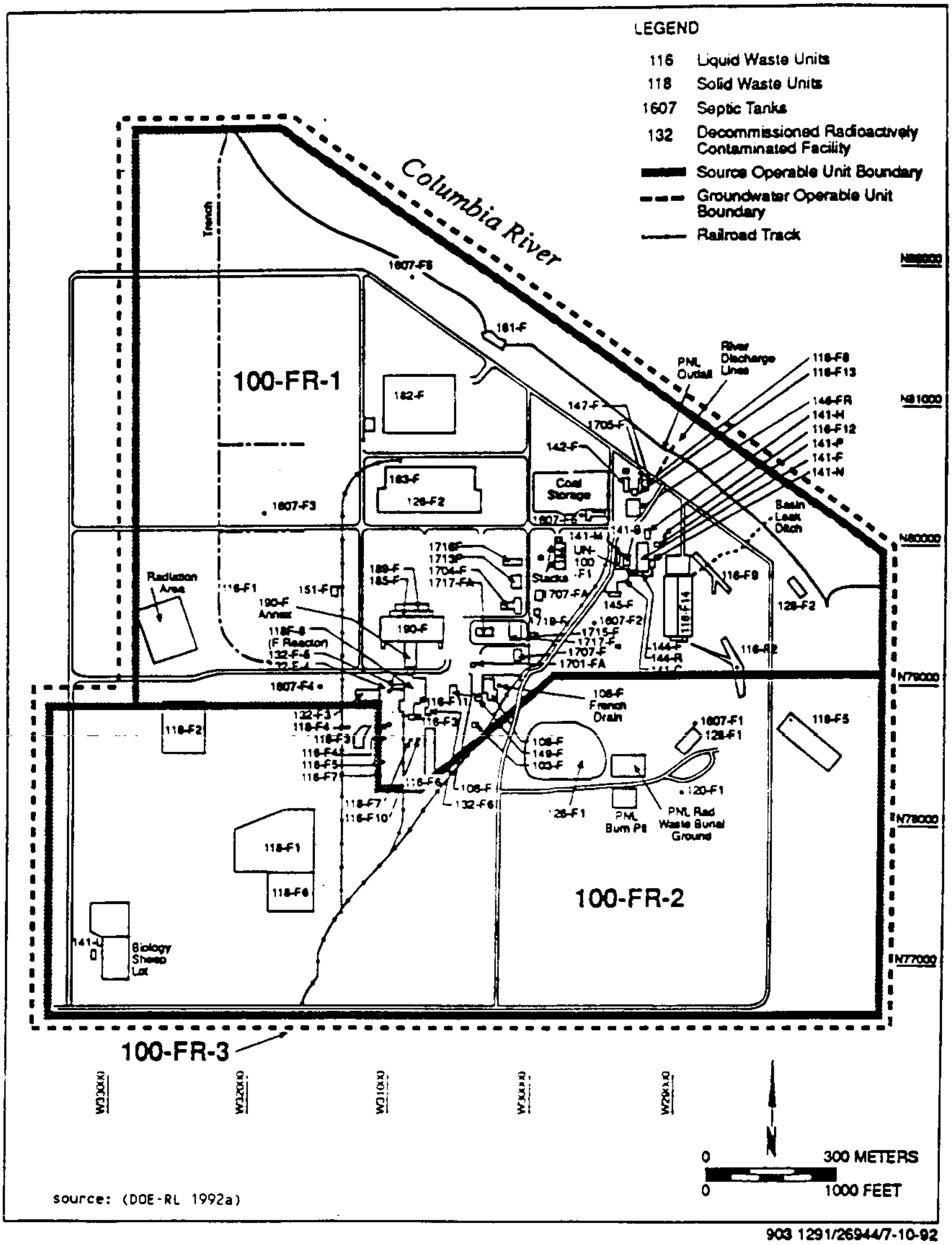

Table 1-1 100-FR-1 Operable Unit High-Priority Sites and Low-Priority Facilities

High-Priority Sites	Low-Priority Sites
116-F-1 Trench *	116-F-7 French Drain +
116-F-2 Trench *+	1607-F Septic tanks and Drain Fields +
116-F-3 Storage Basin Trench *+	132-F-1 Chronic Feeding Barn *
116-F-4 Crib *+	132-F-3 Gas recirculation Facility demolition Site +
116-F-5 Crib	132-F-5 Filter Facility Demolition Site +
116-F-6 Liquid Waste Disposal Trench *	
116-F-8 Outfall Structure +	
116-F-9 Trench *	
116-F-10 French Drain	
116-F-11 French Drain	
116-F-12 French Drain	
116-F-13 French Drain	
116-F-14 Retention Basins *+	
108-F French Drain *	
Process/Discharge Pipelines	
UN-100-F-1 Spill	
132-F-6 Waste Water Pumping Station	
PNL Outfall Structure	

* = Additional sampling conducted as part of a limited field investigation
+ = Additional data from an analogous facility (DOE-RL 1992a)
PNL = Pacific Northwest Laboratory

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2.0 INVESTIGATIVE APPROACH

The LFI activities for the sites identified in the 100-FR-1 Operable Unit Work Plan (DOE-RL 1992a) consisted of intrusive investigations, review of analogous site information, evaluation of historical data, and completion of a QRA. Through this process, investigations of all of the high-priority sites identified in the 100-FR-1 Operable Unit Work Plan (DOE-RL 1992a) and one low-priority facility were completed.

The work plan divides the site characterization activities into 13 tasks (including this LFI report) most with several subtasks. Table 2-1 lists these tasks and subtasks, which were accomplished as part of the LFI, and the chapters in the LFI where the activities are discussed. Additional reports that were generated as a result of the activity are also referenced.

The LFI activities as well as the aggregate area investigations are discussed in greater detail in the following sections. Results of 100-FR-1 Operable Unit field investigation activities are discussed in Chapter 3 of this report.

2.1 100-FR-1 LFI SAMPLING AND FIELD ACTIVITIES

Field activities used to evaluate contamination at the high-priority sites identified in the 100-FR-1 Operable Unit Work Plan (DOE-RL 1992a), included cable-tool drilling of boreholes; backhoe excavations of test pits; field screening for evidence of volatile organics, chromium, and radionuclides; sampling for physical properties and analytical constituents; and borehole geophysical logging. The description of work (Ayres 1993a) provided direction for these field activities.

Investigative methods were used which allowed appropriate sample extraction. After the desired samples were taken, they were shipped offsite for laboratory analysis using Contract Laboratory Program (CLP) and other standard analytical procedures. Analytical methods, analytical parameters, detection limits, and precision and accuracy requirements are listed in Table QAPjP-1 of the Quality Assurance Project Plan in the 100-FR-1 Operable Unit Work Plan (DOE-RL 1992a). The analytical results were returned for validation and evaluation.

Nonintrusive investigations of high-priority sites relied on historical data from past sampling and analysis (Dorian and Richards 1978), and process knowledge. Ground penetrating radar surveys were performed prior to investigations to locate subsurface obstructions that might affect borehole drilling or test pit excavation. Based upon survey results, drill sites with the least likelihood of encountering identified obstructions were recommended. A surface radiological survey was performed at the 116-F-14 retention basins as part of routine work to downgrade sites from a surface contamination area. In addition, a surface-area walkover of the 100-FR-1 Operable Unit was done. The investigative approach taken at each high- and low-priority site is summarized in Table 2-2.

Analogous data from intrusive LFI in the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units were applied to the LFI evaluation of several sites in the 100-FR-1 Operable Unit. Each of the reactors and their support facilities in the 100 B/C, 100 H, and 100 D/DR are similar in construction and use. Analogous data were utilized if no LFI data or historical data were available. An analogous site is a site associated with one of the other 100 Area reactors which has a similar process history, waste stream, and expected suite of contaminants to a site in the 100-FR-1 Operable Unit. An analogous site does not necessarily have the same geology or contaminant concentrations. Table 2-3 presents 100 Area analogous sites.

2.1.1 Vadose Zone Borehole Drilling and Test Pit Excavation

Six boreholes were drilled at the 100-FR-1 Operable Unit to determine the nature and vertical extent of contamination associated with the following high-priority waste sites:

- 116-F-1 lewis canal
- 116-F-2 basin overflow trench
- 116-F-6 liquid waste disposal trench
- 116-F-9 Pacific Northwest Laboratory (PNL) animal waste leach trench
- 116-F-14 retention basin
- 116-F-4 pluto crib.

The location of the boreholes within each facility was chosen to represent the "worst case" contamination, such as near locations of effluent inflow to the facility, or near the center of the facility if the discharge point could not be determined (See Figure 2-1 for sampling locations). These boreholes were advanced using cable-tool drilling methods and were sampled with split-spoon samplers. The depth of each borehole was based on expected waste depth and modified in the field based upon field screening results for radionuclides, and volatile organic compounds (VOC) (DOE-RL 1992a). Field screening for hexavalent chromium was performed on the last sample interval of each borehole. The hexavalent chromium field screening is for general information only and was not used for any decision making process for this report. Maximum drilling and sampling depth was 1.5 m (5 ft) below the water table (Ayres 1993a). Boreholes were abandoned after all sampling and geophysical logging were completed in accordance with Environmental Investigation Instruction (EII) 6.7 (WHC 1988).

Five test pits were excavated (as part of Task 5) at waste sites in the operable unit:

- High-Priority Sites:
  - 116-F-1 lewis canal (2 test pits) to depths of 5.5 and 6.0 m (18 and 20 ft)
  - 116-F-3 fuel storage basin trench to a depth of 5.2 m (17 ft)
  - 116-F-9 PNL animal waste leach trench to a depth of 5.8 m (19 ft).

- Low-Priority Site:
  - 132-F-1 chronic feeding barn to a depth of 1.8 m (6 ft).

A backhoe was used to extract the soil material from the test pits and to remove fill material that overlies the sites. The samples from the test pits were collected directly from the backhoe bucket using hand tools and standard soil sampling techniques per EII 5.2, Appendix I, (WHC 1988). The procedure was to remove a bucket of soil from the desired sampling interval and bring it to the side of the test pit for sampling. Samples were collected from soil in the middle of the bucket, away from the bucket sides. Excavated soil was screened for radionuclides, VOC and chromium. The chromium screening was not performed at each test pit.

A proposed borehole (DOE-RL 1992a) was to be drilled at the 108-F french drain. To be more cost effective a grab sample was taken in place of the borehole at this french drain. An auger was used to obtain two soil samples. The first soil sample was collected from 1 ft to 1.5 ft and the second was taken at 3.5 ft.

2.1.2 Field Screening

All material excavated from boreholes and test pits was field screened for evidence of VOC and radionuclides. The screening was done to assist in the selection of sample intervals and borehole total depths. The volatile organics were screened using an organic vapor monitor (OVM), that was used, maintained, and calibrated consistent with EII 3.2, Health and Safety Monitoring Instruments, and EII 3.4, Field Screening (WHC 1988). Radionuclides were screened by the field geologist, and all sample screening data were recorded on the borehole logs per EII 9.1, Geologic Logging (WHC 1988).

An action level was set for sampling radionuclides at twice the local background level. The sampling action level for VOC was set at 5 ppm above background. The background levels were determined prior to initiating drilling or excavation at a chosen background site located outside of the operable unit. This information was recorded in the field log book (or geologic log for boreholes).

Hexavalent chromium screening was performed on soil samples from the final sample interval using a portable hexavalent chromium test kit. The detection limit for the chromium test kits was 10 ppm. The chromium screening was done for informational purposes only and was not used in any decision making processes in this report; therefore, an action level was not set.

2.1.3 Geophysical Logging

All boreholes were logged using a spectral gamma ray radiation logging system in accordance with EII 11.1 (WHC 1988). The objective of the borehole surveys was to identify the presence and type of man-made gamma ray emitting radionuclides and the relative activity levels. No geophysical logging was performed in the test pits.

2.1.4 Sampling

Four types of samples were collected (as part of Task 5) during borehole and test pit excavation: geologic samples (borehole), physical properties samples (borehole), analytical samples (borehole and test pit), and archive samples (borehole). Geologic samples were taken at approximately 5 ft intervals and at major stratigraphic changes to aid in preparation of borehole logs. All of the sampling intervals were logged in feet and are likewise presented in this report (1 ft=0.3048 m).

Four samples for physical properties analyses were collected from the borehole at the 116-FR-14 retention basin. The physical properties samples were taken at 5 ft intervals. The primary objective for sample collection was to represent the principal soil types.

Analytical samples were collected from the boreholes and test pits in accordance with EII 5.2, Soil and Sediment Sampling (WHC 1988). One sample was collected from the surface soil at each borehole and test pit location prior to drilling or excavation. The remaining analytical samples were collected based on the following criteria:

- If drill cuttings or exposed material in the backhoe were greater than or equal to the action level for radionuclides (2X background) or VOC (5 ppm greater than background), an analytical sample was collected at that point and sampling continued at 5-ft intervals until two consecutive samples had radionuclides or VOC field screening results less than the screening criteria.

- If drill cuttings or exposed material in the backhoe were less than the established action level for radionuclides and VOC, the material from the test pit or borehole continued to be screened. An analytical sample was collected at the maximum expected waste depth and sampling continued at 5 ft intervals until two consecutive samples passed the screening criteria.

2.2 AGGREGATE AREA INVESTIGATIONS

The 100 Area aggregate studies and Hanford Site studies provide integrated analyses of selected issues on a larger scale than the operable unit. The 100-FR-3 Groundwater Operable Unit Work Plan (DOE-RL 1992b) addresses activities common to the 100 Area such as a river impact study, shoreline studies, ecological studies, and cultural resource studies. These studies provide data to be used in the LFI and in the selection of final remedies.

2.2.1 100 Area Topography

The 100 Area operable units are topographically and environmentally similar. Each is situated along the Columbia River bank, with the reactor located on a high gravel terrace left by the recession of glacial floodwaters at the end of the Pleistocene. Shoreline areas grade from steep banks with narrow cobble beaches to broad, stepped, well-defined floodplain terraces with gently sloping beaches. The floodplain terraces consist of sand deposited during the Holocene and occur on at least two levels, one dating to the early or middle Holocene and another representing the later Holocene. Inland areas are broad flats broken only by stabilized dunes. The area from west of the 100 N Area to the western edge of the 100 D Area differs from this general pattern. Information on the geology specific to the F Area can be found in *Geology of 100-FR-3 Operable Unit Hanford Site, South-Central Washington* (Raidl 1993).

2.2.2 Ecological Investigation

Ecological surveys of the 100 F Reactor area were completed as described in Appendix D-2, Ecological Investigations, of the 100-FR-3 Operable Unit Work Plan (DOE-RL 1992b).

Ecological surveys and sampling, related to CERCLA activities, have been conducted in the 100 Areas and in and along the Columbia River adjacent to the 100 Areas. The field investigations concentrated on bird surveys, mammal and insect surveys, vegetation surveys, and sampling of other various biota for radionuclides and inorganic waste constituents. Biota and soil samples were collected from species and media with either a past history of documented contaminant uptake or an important position in the food web. Sampling included reed canary grass, tree leaves, asparagus, soil excavated from mammal burrows, ant mounds, raptor pellets, and coyote scat. These samples were analyzed for target analyte list (TAL) analytes and selected radionuclides. The results of these sample analyses have been compiled and are presented in Landeen et al. (1993). Other sampling results generated by sitewide surveillance and facility monitoring programs that can be used in the evaluation of ecological contamination are presented in Weiss and Mitchell (1992).

Except for zinc in asparagus, Landeen et al. (1993) did not note any probable contamination in environmental samples collected from the 100 F Area. Samples from asparagus collected in the 100 F Area showed zinc concentrations as high as 97 ppm (average control sample concentration was 61.75 ppm). Concentrations of other analytes (inorganics and radionuclides) did not differ appreciably from collected control samples.

The area included within the former boundaries of 100 F Area is primarily dominated by cheatgrass (*Bromus tectorum*) and rabbitbrush (*Chrysothamnus spp.*). Sand dropseed (*Sporobolus cryptandrus*) can be found along the roadways. There are also numerous, although scattered, remnant trees, including sycamores, mulberries, junipers, elms, and poplars.

The shoreline adjacent to the 100 F Area is very steep, with a narrow riparian zone. Much of the shoreline consists of large cobbles and boulders. At the southern end of the boundaries of the 100 F Area the shoreline abruptly flattens into a rocky plain that eventually graduates into the backwater, wetland area known as F slough. The rocky plain has populations of lupine (*lupinus spp.*) and Gray's desertparsley (*Lomatium grayi*).

2.2.3 Cultural Resources Review

In compliance with Section 106 of the National Historic Preservation Act, and at the request of WHC, the Hanford Cultural Resources Laboratory conducted an archaeological survey of the 100 Area reactor compounds on the Hanford Site. This survey was conducted as part of a comprehensive cultural resources review of the 100 Area Operable Units in support of CERCLA characterization activities. The work included a literature and records review and pedestrian survey of the project area following procedures established in the *Hanford Cultural Resources Management Plan* (Chatters 1989).

Archeological surveys were completed at the 100 F Reactor Area (part of task 9) as directed in the 100-FR-3 Groundwater Operable Unit Work Plan (Appendix D-3, Cultural Resources Investigations) (DOE-RL 1992b).

Six archaeological sites were recorded in the 100-FR-1 Operable Unit during the cultural resource survey (Chatters et al. 1992). Two of the sites are turn-of-the-century homesteads, three are of undetermined age, and one dates back to the Cascade Phase (Chatters et al. 1992). Before doing work that may impact these sites cultural resource personnel must be notified.

2.3 SAMPLE ANALYSIS

Samples collected for chemical analysis were analyzed for the suite of CERCLA target compound list and TAL constituents, specific anions, and radionuclides. Chemical analysis was conducted using CLP methods. Analytical methods, routine analytical detection and quantitation limits, and precision and accuracy specified for the methods are listed in Appendix A, 100-FR-1 Operable Unit Work Plan (DOE-RL 1992a).

Samples collected for physical properties were evaluated using American Society for Testing and Materials (ASTM) procedures, except bulk density. Bulk density was calculated using a method developed by the laboratory contractor. The following parameters were analyzed and/or calculated (includes applicable ASTM method numbers):

- bulk density
- particle size distribution (ASTM D422-63)
- moisture content (ASTM D2216)
- moisture retention (ASTM D2325-68, D3152-72)
- saturated hydraulic conductivity (ASTM D2434-68).

2.4 DATA VALIDATION

Data validation was performed by a qualified independent participant contractor. Data validation was performed in compliance with WHC *Sample Management and Administration Manual* (WHC 1990). All data packages were assessed. The chemical and radiological analytical data were validated, but physical properties data were not. Results of the data validation are presented in separate reports (Ayres 1993b and 1993c).

In addition to the data validation identified above, the LFI data were evaluated for use in the LFI and QRA. This evaluation included (1) an inventory of all samples collected during the LFI, (2) data compilation and review, and (3) a review of laboratory and field (including trip and equipment) blanks. The sample inventory was conducted using multiple information sources including project sample lists, borehole logs, sample tracking sheets, and sample location maps.

Data compilation was done to verify that validation results were incorporated into the analytical database and that the data qualifiers were listed. Rejected data were assigned the qualifier "R". Data rejected for major quality deficiencies (e.g., technical concerns) were not used, however data rejected for administrative reasons (missing documentation) were considered usable for the LFI and QRA. Data sources were Hanford Environmental Information System, CLP analysis data disks, validated analytical reports, i.e., "Form 1" sheets, and CLP data packages.

Laboratory and field blanks were used to evaluate each data set for common laboratory contaminants or sources other than media contamination. This review was conducted using the EPA's "five or ten times rule" (EPA 1988). The ten times rule applies to common laboratory contaminants, e.g., 2-butanone, acetone, methylene chloride, toluene, and common phthalate esters. Detected concentrations of common lab contaminants had to be >10 times their corresponding blank value to be considered valid. Detected concentrations of other contaminants had to be >5 times their corresponding blank value to be considered valid.

Data marked with "J" or "R" qualifiers were used for the LFI and QRA as indications of contamination present, as were data that had no qualifiers attached. Data that were marked with "U" or "UJ" qualifiers were not used because these qualifiers indicate no contamination is present above specified value. Data that were marked with "B" qualifiers were evaluated using the EPA five and ten times rule to assess if they were usable.

2.5 HANFORD SITE BACKGROUND

Results of the characterization of the natural chemical composition of Hanford Site soils is presented in *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes* (DOE-RL 1993a). The characterization included an analysis of physical properties and factors that might affect the natural soil chemical composition, as determined by regulatory protocols. Hanford Site soils have not been characterized to establish the natural concentrations of the following types of constituents: VOC, semi-volatile organic compounds, pesticides and polychlorinated biphenyl (PCB), and radionuclides. Because sitewide background levels for organic and radionuclide constituents have not been established, all detected concentrations of these constituents were considered as contaminants of potential concern (COPC).

Table 2-4 presents the 95 percentile of the lognormal distribution and the lognormal distribution 95% upper threshold limits (UTL) for inorganic analytes of Hanford Site soils (DOE-RL 1993a). Limited field investigation analytical data for inorganic constituents are considered COPC if they exceed the 95% UTL values.

Figure 2-1 Limited Field Investigation Intrusive Sampling Locations

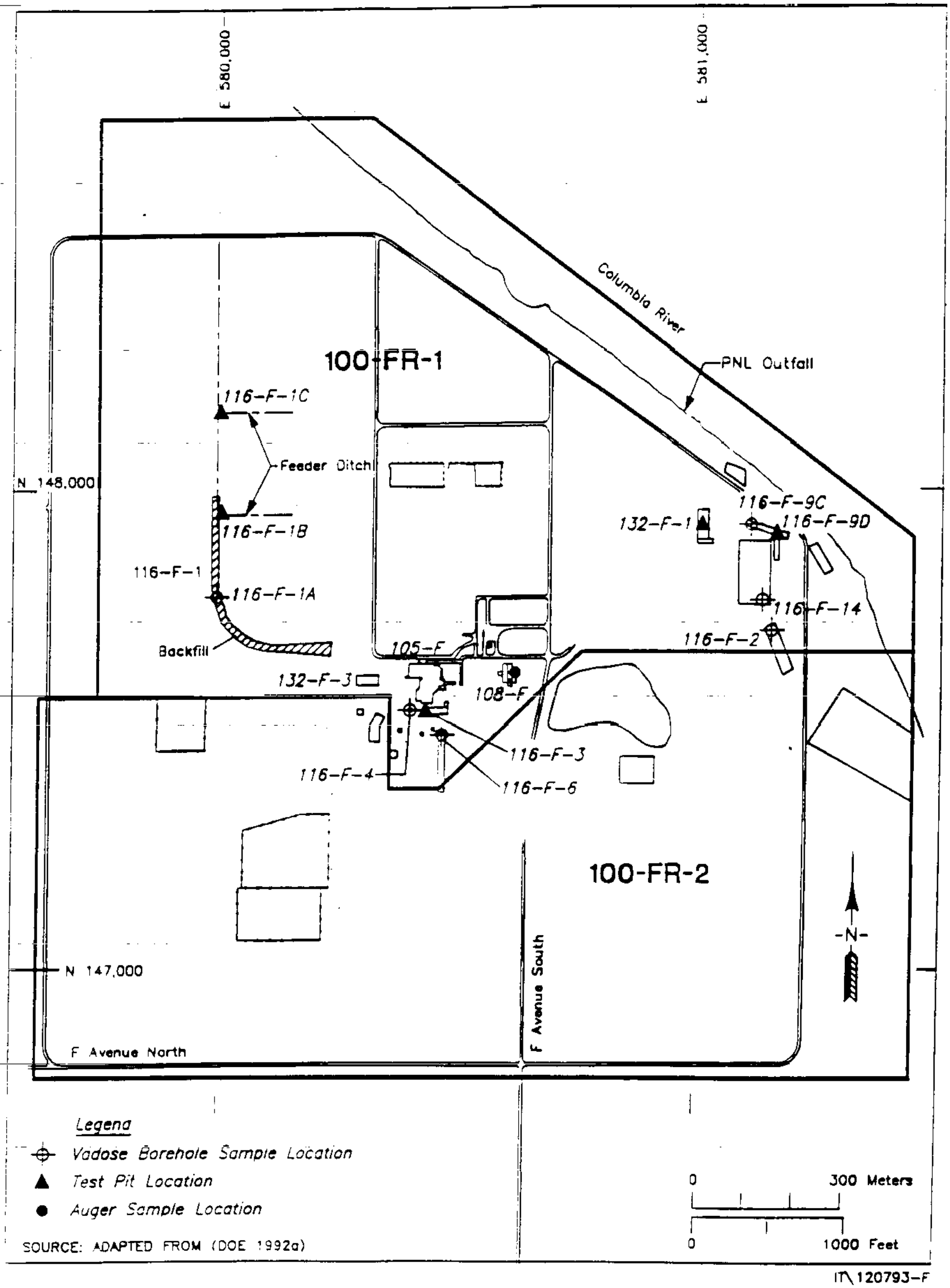


Table 2-1 100-FR-1 Operable Unit Characterization Activities (Page 1 of 2)

Task	Title	Where Addressed
1	Project Management	Accomplished throughout project.
2	Source Investigation	See subtasks below.
2a	Source Data Compilation and Review	Background information is incorporated into the work plan, QRA, and LFI reports as appropriate (for historical information see Deford 1993).
2b	Surveying	Coordinates and locations of sampling sites are documented in the LFI report (Chapter 2 and 3) (see Ayres 1993a for sampling locations).
2c	Field Activities	Field activity results are in the LFI report. Ground Penetrating Radar surveys were completed as part of the LFI (Bergstrom 1993a, Bergstrom 1993b, Bergstrom 1993c, Bergstrom 1993d, Bergstrom 1993e, and Mitchell 1993).
2d	Source Sample Laboratory Analysis and Data Validation	Analytical results and data validation are documented in data validation reports referenced in Chapter 2 of LFI report (Ayres 1993b and Ayres 1993c).
2e	Source Data Evaluation	The data were evaluated for use in the QRA and also evaluated in the LFI report.
3	Geologic Investigation	Coordinated through the 100-FR-3 Operable Unit tasks (Raidl 1993).
4	Surface Water and Sediments Investigation	Not applicable to 100-FR-1.
5	Vadose Zone Investigation	See subtasks below.
5a	Data Compilation	See subtask 2a.
5b	Borehole Soil Sampling and Logging	Results of the borehole investigations are presented in the LFI report (Chapter 3). Borehole logs are displayed in the figures in the LFI report (Chapter 3) (for validated data reference Ayres 1993b).
5c	Test Pit Sampling	Results of test pit investigations are presented in the LFI report (Chapter 3) (for validated data see Ayres 1993b and 1993c).
5d	Soil Sample Analysis	The analysis and validation are documented in the data validation reports referenced in LFI report (Chapter 2) (see Ayres 1993b and Ayres 1993c).
5e	Geophysical Logging	The results in the geophysical logging are reported in the LFI report (Chapter 3 and Appendix B).
5f	Data Evaluation	The data were evaluated for use in the QRA and also evaluated in the LFI report.

Table 2-1 100-FR-1 Operable Unit Characterization Activities (Page 2 of 2)

Task	Title	Where Addressed
6	Groundwater Investigation	Performed as part of the 100-FR-3 Operable Unit activities (reference 100-FR-3 Operable Unit Work Plan [DOE-RL 1992b]).
7	Air Investigation	Routine health and safety monitoring was performed during the field activities.
8	Ecological Investigation	A discussion of the ecological investigation is included in the LFI report (Chapter 2) (for specific details on ecologic activities see Landeen et al. 1993)
9	Other Task	See subtask below.
9a	Cultural Resource Investigation	A discussion of the cultural resource investigation is included in the LFI report (Chapter 2) Chatters 1992 for specific cultural resource investigations).
10	Data Evaluation	Evaluation and interpretation of the data is accomplished is the QRA and LFI reports. The evaluation of the data for other purposes such as large scale remediation, FS activities, and treatability testing is ongoing.
11	Risk Assessment	The data generated during the LFI were used is the QRA.
11a	Human Health Evaluation	The QRA and summarized in the LFI report (Chapter 4).
11b	Ecological Evaluation	The QRA and summarized in the LFI report (Chapter 4).
12	Verification of ARAR	ARAR are listed in the LFI report (Chapter 3).
13	LFI Report	

source: (DOE-RL 1992a)
FS = feasibility study
LFI = limited field investigation
QRA = qualitative risk assessment
ARAR = applicable or relevant and appropriate requirements

Table 2-2 LFI Investigation Activities for 100-FR-1 Operable Unit High-Priority Sites (page 1 of 3)

Site	Name - Size	Comments	LFI Approach
116-F-1	Lewis Canal 914m x 12m x 3m deep	Received liquid waste from F Reactor and 190-F building and decontamination wastes from 189-F Building	B, C, G, F, H, T
116-F-2	107-F Basin Overflow Trench 91m x 15m x 5m deep	Received overflow from 116-F-14 retention basin and F Reactor	B, C, G, F, R, H
116-F-3	105-F Fuel Storage Basin Trench 30m x 3m to 6m x 2.4m deep	Received cooling water effluent and sludge from the F Reactor storage basin	T, C, F, H, R
116-F-4	105-F Pluto Crib	Received cooling water from process tubes containing ruptured fuel elements	Tr, C, B, F, G, R, H
116-F-5	Ball Washer Crib 91m x 30m x 3m deep	Received waste from decontamination of irradiated boron-steel balls	N, H
116-F-6	1608-F Liquid Waste Disposal Trench	Received diverted cooling water effluent during reactor maintenance outages	B, C, G, F, R, H
116-F-8	1904 Outfall Structure 8m x 4m	Received cooling water from retention basin	N, H
116-F-9	PNL Animal Waste Leach Trench (two trenches connected together) - long trench 122m x 5m x 3m deep short section - 30m x 5m x 3m deep	Contaminated wash/waste water from animal pens, containing strontium-90 and plutonium-239	B, C, G, F, R, T, H

Table 2-2 LFI Investigation Activities for 100-FR-1 Operable Unit High-Priority Sites (page 2 of 3)

Site	Name - Size	Comments	LFI Approach
116-F-10	105-F Dummy Decontamination French Drain	Received spent nitric acid and rinse water from the decontamination of fuel element spacers at F Reactor	N,H
116-F-11	105-F Cushion Corridor French Drain 1m x 1m deep	Received cushion corridor decontamination waste	N, H
116-F-12	148-F French Drain 2m x 1m deep	Received overflow, priming water, etc. from 148-F pump house	N, H
116-F-13	1705-F Experimental Garden French Drain 1m x 1m deep	Received cooling water effluent used in botany experiments	N, H
116-F-14	107-F Retention Basin 137m x 70m x 7m deep	Received cooling water effluent from F Reactor and reactor building drains	B, C, P, G, F, H, S, R
	108-F French Drain	Received condensate from hoods inside the 108-F biology laboratory	Gr, H, C
	Process/Discharge Pipelines	Transferred process and reactor discharge effluents	N, H
	UN-100-F-1 (spill)	Main sewage line from 141-C to 141-M became plugged and spread contamination on the ground	N, H
132-F-6	1608-F Waste Water Pumping Station 11m x 10m	Pumped miscellaneous effluent from F Reactor drain systems to the 116-F-14 retention basin	N, H

Table 2-2 LFI Investigation Activities for 100-FR-1 Operable Unit High-Priority Sites (page 3 of 3)

Site	Name - Size	Comments	LFI Approach
	PNL Outfall Structure	Used as an outfall for contaminated wash water for animal pens	N, H

B = Vadose zone borehole - drilling, geologic logging, and sampling
C = Chemical and radionuclide analysis
P = Physical properties analysis of samples
G = Borehole spectral gamma ray geophysical log
F = Field screening for radioactivity, volatile organic compounds, and hexavalent chromium
R = Ground penetrating radar to position boreholes and test pits
T = Test pits
Gr = Grab sample
N = No intrusive investigation
H = Historical data reviewed
Tr = Treatability test
S = Surface contamination survey
PNL = Pacific Northwest Laboratory
LFI = limited field investigation
Source: (DOE-RL 1992a)

Table 2-3 100 Area Analogous Sites

Waste Site Description	100-B/C Area Site	100-D/Dr Area Site	100-H Area Site	100-F Area Site
Process Effluent Disposal Trench	116-B-1 116-C-1	116-DR-1 116-DR-2	116-H-1	116-F-2
Fuel Storage Basin Trench	116-B-2	116-D-1a 116-D-1b	None	116-F-3
Dummy Decontamination French Drain	116-B-4	None	116-H-3	116-F-10
Process Effluent Retention Basin	116-B-11 116-C-5	116-D-7 116-DR-9	116-H-7	116-F-14
Reactor Confinement Seal Pit Drainage Crib	116-B-12	116-D-9	116-H-9	None
Process Effluent Outfall Structure	116-B-7 132-B-6 132-C-2	116-D-5 116-DR-5	116-H-5	116-F-8
Process Effluent Pipelines	Process Effluent Pipelines	Process Effluent Pipelines	Process Effluent Pipelines	Process Effluent Pipelines
Effluent Pumping Station	None	132-D-3	132-H-3	132-F-6
Exhaust Air Filter Building	132-B-4	117-D	132-H-2	None
Pluto Crib	116-B-3 116-C-2a	116-D-2a	116-H-4	116-F-4
Gas Recirculation Building	132-B-5	115-D	None	132-F-6
Cushion Corridor French Drain	None	116-D-6	None	116-F-11

source: adapted from (DOE-RL 1992a)

Table 2-4 Summary Statistics and Upper Threshold Limits for Inorganic Analytes

Analyte	95% Distribution[a] (mg/kg)	95% UTL[b] (mg/kg)
Aluminum	13,800	15,600
Antimony	NR*	15.7[c]
Arsenic	7.59	8.92
Barium	153	171
Beryllium	1.62	1.77
Cadmium	NR	0.66[c]
Calcium	20,410	23,920
Chromium	23.4	27.9
Cobalt	17.9	19.6
Copper	25.3	28.2
Iron	36,000	39,160
Lead	12.46	14.75
Magnesium	7,970	8,760
Manganese	562	612
Mercury	0.614	1.25
Nickel	22.4	25.3
Potassium	2,660	3,120
Selenium	NR	5[c]
Silver	1.4	2.7
Sodium	963	1,290
Thallium	NR	3.7[c]
Vanadium	98.2	111
Zinc	73.3	79
Molybdenum	NR	1.4[c]
Titanium	3,020	3,570
Zirconium	47.3	57.3
Lithium	35	37.1
Ammonia	15.3	28.2
Alkalinity	13,400	23,300
Silicon	108	192
Fluoride	6.4	12
Chloride	303	763
Nitrite	NR	21[c]
Nitrate	96.4	199
Ortho-phosphate	3.7	16
Sulfate	580	1,320

Source: DOE-RL 1993a

* NR = Not Reported

[a] 95th percentile of the data for a lognormal distribution

[b] 95% confidence limit of the 95th percentile of the data distribution

[c] Limit of detection

3.0 INVESTIGATION RESULTS AND CONCLUSIONS

This chapter presents results and conclusions from the investigations of the high-priority sites, and at one low-priority site in the 100-FR-1 Operable Unit. Sections 3.1 through 3.8 address the eight high-priority sites where intrusive field activities occurred. Sections 3.9 through 3.18 address the nonintrusive investigations that occurred at the remaining high-priority sites. Section 3.19 presents results of sampling at the 132-F-1 low-priority facility. Section 3.20 presents a summary of potential ARAR for the 100-FR-1 Operable Unit.

The following types of data are presented in discussions of the investigated sites:

- Site location, size, characteristics, history, and expected contaminants.
- geologic data obtained during the investigation.
- Analysis of results from offsite laboratory analyses of soils samples for VOC, semi-volatile organic compounds, metals, pesticides, PCB, radionuclides, and on-site laboratory analyses of physical properties. Data validation qualifier codes associated with specific analyses are included in tables at the end of Chapter 3 and in the analytical data appendices.
- Field screening data collected using hand-held instruments during sampling. Field screening was intended to assist in selection of sample intervals and to determine the depth at which drilling and sampling was stopped. Field screening data are qualitative; the identification of specific constituents and their concentrations are provided by the analytical results from the offsite laboratories.
- Borehole spectral gamma geophysical logging results.
- Results of the comparison of data collected during the 1992 LFI and data from previous "historical" investigations at the site.
- Data applicable to the 100-FR-1 LFI that were obtained from the vadose zone during the LFI of the 100-FR-3 Groundwater Operable Unit.
- Concentrations of chromium and strontium-90 in groundwater from monitoring wells downgradient and upgradient of the high-priority sites are reviewed to assess the potential impact on groundwater in the uppermost unconfined aquifer. Chromium and strontium-90 were dominant risk-drivers for the 100-FR-3 groundwater as analyzed in the 100-FR-3 QRA and LFI (DOE-RL 1994b).

3.1 116-F-1 LEWIS CANAL

The 116-F-1 (lewis canal) is an inactive liquid waste site that operated from 1953 to 1965. The canal is an unlined surface drainage feature measuring approximately 914 m (3000 ft) long and 12 m (40 ft) wide, with an average depth of 3 m (10 ft). The headwall is located 229 m (750 ft) northeast of the reactor building where the canal flows to the west but immediately bends northward and terminates at the Columbia River. The southern third (upstream) of the 116-F-1 trench is marked by permanent concrete monuments and "Underground Radioactive Material" warning signs. This portion of the trench has been fully backfilled and is covered with large cobbles. It continues to be treated with herbicides and no vegetation grows on its surface. Its headwall has also been buried and no portion of it is visible. The northern (downstream) two-thirds has no monuments or warning signs place.

Two 1.2 m (4 ft) deep feeder ditches drained into the canal. The southern (upstream) feeder ditch provided drainage for the 183-F filter plant and the northern (downstream) feeder ditch provided drainage for the 182-F reservoir and pump house. The southern (upstream) feeder ditch has been backfilled and is covered with grass and no monuments or warning signs mark this ditch. The ditch was fed by a 1.2 m (48 in.), extra-strong, reinforced concrete pipe before decommissioning, and it is unclear if this pipe remains in place (Deford 1993). The northern (downstream) feeder ditch has not been backfilled. It has a concrete headwall that is protected by a double-railed wooden fence in poor repair. The opening in the headwall reveals a 1.2 m (48 in.) reinforced concrete pipe running from the direction of the 182-F building. The headwall area is filled with tumbleweeds. No monuments or warning signs mark this ditch.

An estimated 100,000,000 l of waste entered 116-F-1 from 105-F, 182-F, 189-F, and 190-F buildings. In addition to radionuclide contamination, 116-F-1 also received approximately 100 kg (220 lbs) of sodium dichromate and an estimated 10,000 kg (22,000 lbs) of sulfamic acid (DOE-RL 1992a).

Figure 3-1 shows the locations of borehole 116-F-1A, and testpits 116-F-1B and 116-F-1C that were investigated during this LFI.

3.1.1 Geology

This site is characterized by fill material to a depth of approximately 8 ft bls. The 0 to 4 ft bls interval is composed of gravelly sand (approximately 80% sand). The soils from 4 to 22 ft bls (total depth of borehole 116-F-1A) are composed of sandy gravel (Figure 3-4).

3.1.2 116-F-1A Borehole Soil Samples

The 116-F-1A vadose zone borehole was drilled to a total depth of 6.1 m (22 ft) bls. Four soil samples were collected for chemical and radionuclide analysis; B080N1 (0-2 ft bls), B080N2 (9.5-11 ft bls), B080N3 (14.5-16.2 ft bls), and B080N4 (18 to 20 ft bls). Figure 3-6 is a summary diagram of the 116-F-1A borehole.

3.1.2.1 Chemical Analysis. Volatile organic compounds acetone, methylene chloride, and toluene were detected in 116-F-1A. Toluene was detected in all four soil samples. The maximum detection was in sample B080N4 (36 μg/kg) and was the only VOC that was detected above the contract required quantitation limit (CRQL) 10 μg/kg. The volatile organic analytical results are presented in Table 3-1.

Semi-volatile organic compounds bis-(2-ethylhexyl)phthalate and di-n-butylphthalate were detected in sample B080N1 at 360 and 120 μg/kg respectively. Di-n-butylphthalate was also detected in samples B080N2 and B080N3 at 130 and 150 μg/kg, respectively. Sample B080N4 was not analyzed because of a broken sample container. The detected semivolatile organic analytical results are presented in Table 3-1.

No pesticides or PCB compounds were detected in samples B080N1, B080N2, or B080N3. No analytical results were obtained from sample B080N4 due to a broken container.

The concentrations of arsenic (44 mg/kg) and lead (207 mg/kg) in sample B080N1 exceed the Hanford Site background 95% UTL values of 8.92 mg/kg and 14.75 mg/kg. No other inorganics were detected above the Hanford Site background 95% UTL. The detected inorganic analytical results are presented in Table 3-1.

3.1.2.2 Radionuclide Analysis. Table 3-1 presents a summary of the detected radionuclides. Gross alpha was detected at 5.5 pCi/g in sample B080N1, gross alpha was not detected below this interval. Gross beta levels were from 13 pCi/g to 21 pCi/g. The maximum detected radionuclide was carbon-14 at 220 pCi/g in sample B080N2. The only other radionuclide detected above 1 pCi/g was potassium-40, with a maximum of 12 pCi/g in sample B080N1.

3.1.2.3 Field Screening. The well site geologist performed field screening for VOC using an OVM photoionization detector (PID). Ambient VOC background at the start of drilling was 0.6 ppm. No VOC were detected during the investigation of this site.

Radioactivity was monitored during drilling using a Ludlum 14C portable scintillation detector with a gross gamma probe. The gross gamma background level for the site was 1,800 cpm, and gross gamma action level was 3,600 cpm. The maximum observed gross gamma level was 2,500 cpm in the 2 ft to 4 ft bls interval which is within the fill material. Background levels were not exceeded in the interval from 4 ft to 22 ft bls (total depth of borehole).

The well site geologist also performed an analysis for hexavalent chromium on the soil at 22 ft bls. No chromium was detected.

3.1.2.4 Geophysical Borehole Logging. Borehole 116-F-1A was logged from 0 ft to 16.5 ft bls; 5.5 ft less than total depth. The man-made radionuclides detected were:

cobalt-60, cesium-137, europium-152, europium-154. The man-made radionuclides all peaked in activity between 1 ft and 6.5 ft bls. The maximum levels detected for all the man-made radionuclides were found at the 3.5 ft bls interval. Cesium-137 was detected from 1 ft to 5.5 ft bls, with a maximum calculated activity of 4 pCi/g. Cobalt-60 was detected from 1 ft to 5 ft bls, with a maximum calculated activity of 4 pCi/g. Europium-152 was detected from 1 ft to 5.5 ft bls, with a maximum calculated activity of 20 pCi/g. Europium-154 was detected from 1 ft to 6.5 ft bls, with a maximum calculated activity of 3 pCi/g.

3.1.3 116-F-1B Test Pit Soil Samples

The total depth of the 116-F-1B test pit was 17 ft bls. Soil sample numbers and depths were: B08G65 at 1 ft, B08G66 at 5 ft, B08G67 at 10 ft, and B08G68 at 15 ft bls. Figure 3-7 is a summary diagram of the 116-F-1B test pit.

3.1.3.1 Chemical Analysis. Volatile organic compounds detected above the CRQL (10 μg/kg) were acetone and toluene. The maximum concentration of toluene was in sample B08G65 (42 μg/kg). The maximum detected concentration of acetone was in sample B08G68 (13 μg/kg). Table 3-2 presents a summary of the detected VOC in the 116-F-1B test pit.

No semi-volatile organic compounds were detected above the CRQL of 330 μg/kg. Table 3-2 presents a summary of the semi-volatiles that were detected.

No pesticides or PCB were detected.

No inorganic constituents or metals were detected in concentrations above the Hanford Site background 95% UTL.

3.1.3.2 Radionuclide Analysis. The following radionuclides were detected: potassium-40, cesium-137, radium-226, thorium-228, and thorium-232, uranium-233/234, uranium-238. Gross alpha ranged from 7 pCi/g in sample B08G68 to 12 pCi/g in sample B08G65. Gross beta readings were constant at 16 pCi/g with the exception of sample B08G65 (14 pCi/g). The maximum radionuclide concentration was 14 pCi/g of potassium-40 in sample B08G65 and in B08G67. All other radionuclide detections were <1 pCi/g. Table 3-2 provides a summary of the radionuclide detections.

3.1.3.3 Field Screening. The well site geologist performed field screening for VOC using an OVM PID. No VOC were detected during the investigation of test pit 116-F-1B.

Radioactivity was monitored during drilling using a Ludlum 14C portable scintillation detector with a gross gamma probe. No radiation was detected above background during the investigation of the 116-F-1B test pit.

The hexavalent chromium field test was not performed on the last sample due to sluffing of the walls of the test pit.

3.1.4 116-F-1C Test Pit Soil Samples

The total depth of the 116-F-1C test pit was 20 ft bls. Nine soil samples, four of which were quality control (QC) samples, were collected and submitted for chemical and radiological analysis. The sampling intervals were: 1 ft, 5 ft, 10 ft, 15 ft and 20 ft bls. Figure 3-8 is a summary diagram of the 116-F-1C test pit.

3.1.4.1 Chemical Analysis. Volatile organic compounds that were detected above the CRQL were: acetone (15 μg/kg), methylene chloride (12 μg/kg), and toluene (57 μg/kg), all of which were detected in the 1 ft interval. Methylene chloride was only detected in the split sample. Concentrations for acetone and toluene are questionable due to the presence of contamination in the field blank sample. Table 3-3 presents the detections of volatile organics in the 116-F-1C test pit.

Bis(2-ethylhexyl)phthalate was detected at 470 μg/kg in the surface (split) sample, no other detections were above the CRQL in the 1 ft interval or in the 116-F-1C test pit. Table 3-3 presents a summary of the semi-volatile detections.

No pesticides or PCB were detected.

Zinc (142 mg/kg) in the surface sample was the only inorganic above the Hanford Site background 95% UTL. Table 3-3 presents a summary of the detected inorganic compounds.

3.1.4.2 Radionuclide Analysis. The radionuclides detected were: potassium-40, strontium-90, cesium-137, radium-226, thorium-228, thorium-232, uranium-233/234, and uranium-238. Gross alpha ranged from 6.4 pCi/g in the 20 ft bls interval to 14 pCi/g in the surface sample. Gross beta ranged from 13 pCi/g in the 10 ft interval to 35 pCi/g in the surface sample. All radionuclides were $\leq$1 pCi/g, with the exception of potassium-40. Table 3-3 presents a summary of the radionuclide detected.

3.1.4.3 Field Screening. The well site geologist performed field screening for VOC using an OVM PID. No VOC were detected during the investigation of test pit 116-F-1C.

Radioactivity was monitored during drilling using a Ludlum 14C portable scintillation detector with a gross gamma probe. No radiation was detected above background levels during the investigation of the 116-F-1C test pit.

The well site geologist also performed an analysis for hexavalent chromium on the soil at 20 ft bls. No chromium was detected above the detection limit (10 ppm).

3.1.5 Summary

Volatile organic compounds detected during the LFI of the lewis trench were: acetone, methylene chloride, and toluene. The VOC detections are most likely attributable to sampling media or laboratory contamination. Toluene was detected in borehole 116-F-1A and test pits 116-F-1B and 116-F-1C, the highest concentration of toluene was 57 μg/kg in the 1 ft interval of the 116-F-1C test pit. Acetone was detected slightly above the CRQL in both test pits with a maximum detection of 15 μg/kg in the 1 ft interval of test pit 116-F-1C. Methylene chloride was detected above the CRQL only in 116-F-1C at 12 μg/kg. All maximum VOC were detected in the 1 ft interval sample of test pit 116-F-1C. No historical records indicate that acetone, methylene chloride, or toluene were disposed of in the 100-FR-1 Operable Unit.

Bis(2-ethylhexyl)phthalate was the only semi-volatile organic compound detected above the CRQL (330 μg/kg) with a maximum of 470 μg/kg in the 1 ft interval split sample, values for the 1 ft interval sample and the duplicate sample have values less than the CRQL. (Table 3-3). The uses of phthalates include solvent, plasticizer, plastics, and insecticides. Bis(2-ethylhexyl)phthalate was also used as a vacuum pump oil (Sax and Lewis 1987). No pesticides or PCB were detected.

Inorganic constituents detected above the Hanford Site background 95% UTL were: arsenic, lead, and zinc. Arsenic and lead were only detected in the 116-F-1A borehole in the 0 ft to 2 ft bls sample at 44 mg/kg and 207 mg/kg respectively. Zinc was detected at 142 mg/kg in the 116-F-1C test pit surface sample. No inorganic constituents were detected at levels above the Hanford Site background 95% UTL below 2 ft bls. Historical sampling data for organic, inorganic, and nonradionuclide constituents are not available for comparison.

Radionuclides detected during the lewis canal LFI were: carbon-14, potassium-40, strontium-90, cesium-137, europium-152, radium-226, thorium-228, thorium-232, uranium-233/234, uranium-238, and plutonium-239/240. The maximum gross alpha reading was found in the 116-F-1C test pit surface sample at 14 pCi/g. The maximum gross beta result was found in the 116-F-1C test pit surface sample at 35 pCi/g. Samples in borehole 116-F-1A showed consistent elevated values of carbon-14 with a maximum of 220 pCi/g. Potassium-40 was detected at elevated consistent values with a maximum of 14 pCi/g found in several samples. Both carbon-14 and potassium-40 are naturally occurring radioisotopes. No other radionuclides were detected in excess of 1 pCi/g. Field screening detected radionuclide contamination in the 2 ft to 4 ft bls interval of the 116-F-1A borehole, background levels were not exceeded in the 4 ft to 22 ft interval or in either 116-F-1B or 116-F-1C test pit. Radionuclide detections in laboratory samples verses no detections above background in field screening are likely attributed to differences in their detection limits. Geophysical borehole logging of the 116-F-1A borehole showed maximum levels of man-made radionuclides at the 3.5 ft bls interval.

Dorian and Richards (1978) investigation of the lewis trench consisted of 14 soil borings. The maximum sample depth investigated was 15 ft bls. Radionuclides detected were tritium, cobalt-60, strontium-90, cesium-134, cesium-137, europium-152, europium-154, europium-155, and plutonium-239/240. The maximum levels of radionuclide contamination were found in soil boring "G" at a depth of 3 ft bls. The analytical results and soil boring locations are presented in Appendix A.

No analogous sites were investigated by LFI for comparison.

3.1.6 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F7-2 is located downgradient of the 116-F-1 site. No monitoring well is close enough to be considered an upgradient well. The maximum concentrations of chromium were detected in July of 1993 at 19.3 μg/l. Strontium-90 was not detected in any sampling conducted for the 100-FR-3 LFI for well 199-F7-2. Since no upgradient values were available, the impact on groundwater from the 116-F-1 site could not be determined.

3.2 116-F-2 BASIN OVERFLOW TRENCH

The 116-F-2 basin overflow trench is an inactive liquid waste site that operated from 1950 until 1965. The trench measures 91 m (300 ft) long, 15 m (50 ft) wide, and 4.5 m (15 ft) deep. It received reactor cooling water from the 116-F-14 retention basin during reactor outages due to fuel ruptures. It was also used for the disposal of decontamination fluids generated from decommissioning of the retention basin and water from decommissioning the F Reactor Fuel Storage Basin (DOE-RL 1992a). Contaminated cooling water was diverted to the trench from one side of the retention basin through a 30-cm (12-in) diameter steel pipe that connected the basin outlet with the north end of the trench. However, in 1954 it became necessary to use both sides of the retention basin for cooling water storage and the outlet at the north end was no longer useful for diverting contaminated water. It appears that at that time a bypass ditch was excavated, known as the EM bypass ditch. It extended from the 107-cm (42-in) pipe valve of the retention basin to the center of the 116-F-2 basin overflow trench. The length of the EM bypass ditch, estimated from aerial photographs, is 107 m (350 ft) (Deford 1993). It was used to direct contaminated cooling water to the trench. This ditch is indicated on several facility drawings and can be identified on aerial photographs of the 100 F Area.

An estimated 60,000,000 l of liquid waste entered the 116-F-2 unit. In addition to radionuclide contamination approximately 600 kg (1323 lbs) of sodium dichromate were reportedly disposed of in this trench. The 116-F-2 trench and EM bypass ditch have been fully backfilled and appear today as a cobble covered field (Deford 1993).

Figure 3-2 shows the location of 116-F-2 and the approximate location of the LFI vadose zone borehole. Figure 3.9 is a summary diagram of the 116-F-2 LFI borehole data.

3.2.1 Geology

The 116-F-2 site is covered by fill material to a depth of approximately 15 ft. The 0 ft to 5 ft interval is composed of moist, sandy gravel. The lithology then changes to a moist, gravelly sand from 5 to 7.5 ft bls. From 7.5 ft to 24 ft bls the lithology is sandy gravel. The 24 to 35.7 ft bls (total depth of borehole 116-F-2) interval is composed of dry, gravelly sand (approximately 80% sand).

3.2.2 116-F-2 Borehole Soil Samples

Six samples were collected and submitted for chemical and radiological analysis from the 116-F-2 vadose zone borehole, B080M4 (0 ft to 2 ft bls), B080M6 (10 ft to 12 ft bls), B080M7 (14.8 ft to 16.8 ft bls), B080M8 (19.7 ft to 21.7 ft bls), B080M9 (24.5 ft to 26.5 ft bls), and B080N0 (30 ft to 32 ft bls).

3.2.2.1 Chemical Analysis. Methylene chloride and toluene were the only VOC detected in sample B080N0, with values of 2 μg/kg and 4 μg/kg respectively, both of which were below the CRQL of 10 μg/kg. Table 3-4 presents the VOC analytical results.

The semi-volatile organic compounds detected were benzo(b)fluoranthene (83 μg/kg), chrysene (48 μg/kg), and di-n-butylphthalate (71 μg/kg). All semi-volatiles detected were below the CRQL 330 μg/kg. Table 3-4 presents the semivolatile analytical results.

No pesticides or PCB were detected.

Concentrations of inorganic compounds that exceeded the Hanford Site background 95% UTL were cadmium (1.6 mg/kg), barium (338 mg/kg), chromium (98.1 mg/kg), and zinc (295 mg/kg) (Table 3-4).

3.2.2.2 Radionuclide Analysis. Table 3-4 presents a summary of the detected radionuclides. The highest concentration of radionuclides were in the 10 ft to 12 ft bls interval in fill material. Radionuclides that were detected above 1 pCi/g were: carbon-14, cobalt-60, strontium-90, cesium-137, europium-152, europium-154, and plutonium-239/240. The highest of the radionuclides detected were carbon-14 (230 pCi/g), europium-152 (550 pCi/g), and europium-154 (360 pCi/g). Gross alpha was detected at 10 and 11 pCi/g in samples B080M8 and B080M6. Gross beta ranged between 16 and 350 pCi/g.

3.2.2.3 Field Screening. The well site geologist performed field screening for VOC using an OVM PID. The VOC site background was determined to be 0.0 ppm, and the action level for VOC was 5 ppm. The maximum VOC were in the 10 ft to 12 ft bls interval, at levels of 5.6 ppm and 16 ppm. No other VOC were detected above the action level.

Radioactivity was monitored during drilling using a Ludlum 14C portable scintillation detector. The gross gamma background level for the site was 1,700 cpm, and the gross gamma action level was 3,400 cpm. The beta-gamma activity was monitored using a Geiger-Mueller detector with a P-11 probe. The beta-gamma site background level was 100 cpm. The maximum gross gamma concentration of 15,000 cpm was measured at 14 ft bls. Readings that were above the established action level were found from 10 ft bls to 22 ft bls. All soils screened had beta-gamma activity levels less than site background.

The well site geologist also performed an analysis for hexavalent chromium on the soil at 35.7 ft bls (total depth of borehole). No chromium was detected.

3.2.2.4 Geophysical Borehole Logging. Borehole 116-F-2 was logged from 0 ft to 32 ft bls. The man-made radionuclides detected were: cobalt-60, cesium-137, europium-152, and europium-154. Cesium-137 is present from 5 ft to 32 ft bls, with a broad activity peak from 10 ft to 20 ft bls, and a maximum activity of 19 pCi/g at 14.5 ft bls. Cobalt-60 was detected from 5 ft to 22 ft bls, with a broad activity peak from 8 ft to 18 ft bls, and a maximum activity of 6.3 pCi/g at 14.5 ft bls. Europium-154 was detected from 1.5 ft to 30 ft bls. The maximum activity of 143 pCi/g occurred at 10.5 ft bls. Europium-152 was detected from 6 ft to 20.5 ft bls. The maximum activity of 13.6 pCi/g occurred at 14 ft bls.

3.2.3 Summary

Methylene chloride and toluene were detected in sample B080N0 (30 ft to 32 ft) at concentrations less than the CRQL. Both methylene chloride and toluene are typical laboratory contaminants. Historical records do not indicate that methylene chloride or toluene were disposed of in the 100-FR-1 Operable Unit (DOE-RL 1992a). The maximum semi-volatile organic compound detected was benzo(b)fluoranthene at 83 μg/kg in sample B080M6. No semi-volatile exceeded the CRQL of 330 μg/kg. No pesticides or PCB were detected in samples taken from the 116-F-2 borehole.

Inorganic constituents that exceeded the Hanford Site background 95% UTL were: cadmium, chromium, and zinc in sample B080M6 (10 ft to 12 ft bls), and barium in sample B080M8 (19.7 ft to 21.7 ft bls). Historical sampling data for organic, inorganic, and nonradionuclide constituents are not available for comparison.

Radionuclide contamination was found to exist from surface to total depth of the 116-F-2 borehole. The highest radionuclide contamination was found in sample B080M6 (10 ft to 12 ft). Field screening of radionuclides during drilling detected contamination throughout the borehole, with a maximum gross gamma detection of 15,000 cpm at 14 ft bls. Man-made radionuclides detected during spectral gamma logging of the borehole included: cobalt-60, cesium-137, europium-154, and europium-152. The maximum man-made radionuclide concentration detected during logging was 143 pCi/g of europium-154 at 10.5 ft bls.

Dorian and Richards (1978) investigated four soil borings at the 116-F-2 site and four soil borings in the EM bypass ditch in connection with the 116-F-14 retention basin investigation. The highest radionuclide contamination reported was in the 20 ft to 25 ft interval. The maximum radionuclide detection was europium-152 at a depth of 20 ft bls. The analytical results and soil boring locations of the Dorian and Richards sampling are presented in Appendix A.

Four sites which are analogous to the 116-F-2 site and are located in other source operable units have been examined thus far by LFI. These are 116-B-1, 116-DR-1, 116-DR-2, and 116-H-1. To assess the concept that these sites are analogous, a comparison of radionuclide and chemical analytical results from the LFI samples was performed. Table 3-5 presents a comparison of the maximum detected constituents in the analogous facilities. The radionuclide contaminants present in samples from the five sites are similar. Chromium was detected in concentrations greater than the Hanford Site 95% UTL in four of the five sites. Chromium is not a contaminant in the 116-DR-2 site, cadmium and silver are. Barium was only detected in the 116-F-2 site.

3.2.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). No monitoring wells are positioned close enough to 116-F-2 to accurately assess the impact of this site on the groundwater.

3.3 116-F-3 FUEL STORAGE BASIN TRENCH

The 116-F-3 fuel storage basin trench is located approximately 38 m (125 ft) south of the reactor building and is oriented in an east-west direction. It is 30 m (100 ft) long, 6 m (20 ft) wide, and has a depth of 2.4 m (8 ft). It was used from 1947 to 1951. 116-F-3 received reactor effluent during fuel cladding failure. In 1951, the site also received sludge from the F Reactor fuel storage basin (DOE-RL 1992a).

The trench has been fully backfilled and appears today as an unfenced gravel-covered field. Concrete monuments and "Underground Radioactive Material" warning signs mark a general zone that includes the trench area. No vent pipes or other appurtenances are visible (Deford 1993).

An estimated 7,000,000 l of liquid waste entered this trench (Stenner et al. 1988). In addition to the radionuclide contamination, 4 kg of sodium dichromate were reportedly disposed of in this unit.

Figure 3-1 shows the location of the 116-F-3 site and the approximate location of the test pit investigated for this LFI. Figure 3-10 is a summary diagram of the 116-F-3 test pit.

3.3.1 Geology

The LFI site investigation for the 116-F-3 fuel storage basin trench consisted of one test pit which was sampled from 0 to 17 ft bls. There is no geologic description from this activity, but it is assumed that the lithology is composed of sands and gravels similar to those encountered at other 100-FR-1 waste sites.

3.3.2 116-F-3 Test Pit Soil Samples

The total depth of the 116-F-3 test pit was 17 ft bls. Four soil samples were collected, B08G82 (1 ft bls), B08G83 (7 ft bls), B08G84 (12 ft bls), and B08G85 (17 ft bls).

3.3.2.1 Chemical Analysis. Toluene was detected in the surface sample (B08G82) at 21 μg/kg, and 4-methyl-2-pentanone in the 7 ft sample (B08G83) at 11 μg/kg. No other VOC were detected above the CRQL (10 μg/kg). Table 3-6 presents a summary of the detected VOC.

The semi-volatile organic compounds, fluoranthene and pyrene were both detected at 440 μg/kg in the surface sample (B08G82). No other semi-volatile organic compounds were detected above the CRQL (330 μg/kg). Table 3-6 presents a summary of the detected semi-volatiles.

Toxaphene was detected in sample B08G83 (190 μg/kg) above the CRQL (170 μg/kg). Aroclor-1254, also in sample B08G83, was detected above the CRQL (33 μg/kg) at 180 μg/kg. No other pesticides or PCB were detected in the other three samples. Table 3-6 summarizes the detected pesticides and PCB.

Inorganic compounds that exceeded the Hanford Site background 95% UTL were: barium, chromium, lead, mercury, and zinc. Barium was detected in the surface sample at 378 mg/kg, and was the maximum inorganic concentration detected. No inorganic compounds were detected in concentrations exceeding the 95% UTL values below the 7 ft bls interval. Table 3-6 summarizes the detected inorganic constituents.

3.3.2.2 Radionuclide Analysis. Radionuclides detected in the 116-F-3 were: potassium-40, cobalt-60, cesium-137, europium-152, europium-154, radium-226, thorium-228, thorium-232, uranium-233/234, plutonium-238, uranium-238, plutonium-239/240, and americium-241. The maximum radionuclide concentration was 190 pCi/g of europium-152 in sample B08G83 (7 ft bls). The maximum gross alpha was 7.9 pCi/g in sample B08G84. The maximum gross beta detected was in sample B08G83 (71 pCi/g). Table 3-6 summarizes the detected radionuclides in the 116-F-3 test pit.

3.3.2.3 Field Screening. No VOC were detected above the action level (5 ppm) during the 116-F-3 test pit investigation.

Field screening of radioactivity was performed by the well site geologist using a Ludlum 14C portable scintillation detector. The site gross gamma background was 75 cpm. Readings exceeding site background occurred from 7 ft to 12 ft bls with the maximum reading at 7 ft bls (1500 cpm).

The well site geologist also performed field screening for hexavalent chromium from the 17 ft bls soils. No hexavalent chromium was detected above 10 ppm detection limit.

3.3.3 Summary

Sampling of the 116-F-3 test pit did not show significant amounts of volatile organic contamination. Toluene and 4 methyl-2-pentanone were the only volatiles that were detected above the CRQL. Although toluene and 4 methyl-2-pentanone are probably attributed to sampling media or laboratory contamination, the analyses were not flagged with a "B" qualifier to indicate laboratory blank contamination. Historical records do not indicate that toluene was disposed of in the 100-FR-1 Operable Unit (DOE-RL 1992a). No volatiles were detected during continuous field screening of the test pit. The semi-volatile organic compounds fluoranthene and pyrene were detected in the 0 ft to 1 ft sample. The source of these contaminants in the 100-FR-1 Operable Unit are unknown. No other semi-volatiles were detected in excess of the CRQL. Pesticide and PCB contamination consisted of toxaphene and aroclor-1254, both were detected in sample B08083 (7 ft bls). No inorganic contamination was detected below the 7 ft interval. Inorganic COPC are barium, chromium, lead, mercury and zinc. Historical data are limited to radionuclide analyses only, therefore, a comparison of organic, inorganic and nonradionuclide constituents was not possible.

Dorian and Richards (1978) radiological sampling data from the 116-F-3 site consisted of two soil samples from 18 ft and 20 ft. All radionuclides detected measured < 1 pCi/g, and the highest detection during field screening (using a P-11 probe) was 30 cpm at 20 ft. Limited field investigation analyses indicated maximum radiological contamination in sample B08G83 (7 ft bls), with europium-152 being the highest detected value at 190 pCi/g. Field screening for radionuclides also showed the highest detections in the 7 ft interval, with readings exceeding background levels from 7 ft to 12 ft bls. Analytical results and soil boring locations are presented in Appendix A.

Three sites which are analogous to the 116-F-3 site and are located in other source operable units have been examined thus far by LFI. These are 116-B-2, 116-D-1a, and 116-D-1b. To assess the concept that these sites are analogous, a comparison of radionuclide and chemical analytical results from the LFI samples was performed. Chromium and lead were detected in three of the four analogous sites. Barium was only detected in the 116-F-3 samples. Little similarity exists for VOC, semi-volatiles, or pesticide/PCB contamination between the analogous sites. Radionuclide contaminants in the analogous sites were found to be similar to those found at 116-F-3. Table 3-7 presents a comparison of the maximum detected constituents in the analogous facilities.

3.3.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring wells 199-F5-47 and 199-F5-4 are downgradient of site 116-F-3. No monitoring well is located close enough to this site to be considered an upgradient well. In well 199-F5-47 the maximum detection of chromium was 20.7 μg/l in April of 1993. The maximum level of strontium-90 was detected in April 1993 at 3.8 pCi/l. In well 199-F5-4 the maximum detection of chromium was 19.7 μg/l in April of 1993. Strontium-90 was not detected in well 199-F5-4. Since no upgradient values were available, the impact to groundwater from the 116-F-3 site could not be determined.

3.4 116-F-4 PLUTO CRIB

The 116-F-4 (pluto crib) is an inactive liquid waste site that operated from 1950 to 1952. The crib is a 3 m (10 ft) by 3 m (10 ft) by 3 m (10 ft) deep wooden vault located 36.5 m (120 ft) southwest of the 105-F Reactor. 116-F-4 received liquid waste from the 105-F Reactor during outages due to fuel ruptures. The site was excavated in 1993 after LFI activities as a part of the 100 Area Excavation Treatability Test Plan and is no longer in place.

An estimated 4,000 l of cooling water contaminated with 280 Ci of fission products was discharged to this crib from reactor process tubes. The pluto crib also reportedly received approximately 0.004 kg of sodium dichromate (Deford 1993).

Figure 3-1 shows the location of the 116-F-4 pluto crib and the approximate location of the vadose zone borehole investigated for this LFI. Figure 3-11 is a summary diagram of the LFI borehole data.

3.4.1 Geology

The 116-F-4 site is characterized by approximately 9 ft of fill material above native sediments. Soils include the following: sandy gravel from 0 to 9 ft bls, gravelly sand from 9 to 16 ft bls, and sandy gravel from 16 to 28 ft bls (total depth of the 116-F-4 borehole).

3.4.2 116-F-4 Borehole Soil Samples

Six soil samples were taken and submitted for chemical and radionuclide analysis in the 116-F-4 borehole. Samples numbers and intervals were as follows: B080P2 (0 to 2 ft bls), B080P3 (5 ft to 7 ft bls), B080P4 (9.4 ft to 11.4 ft bls), B080P5 (13.4 to 15.6 ft bls), B080P9 (19 ft to 20.8 ft bls), and B080Q3 (25 ft to 26.8 ft bls).

3.4.2.1 Chemical Analysis. The VOC detected above the CRQL of 10 μg/kg were, 2-butanone, acetone, and toluene. Methylene chloride was detected at levels below the CRQL. Acetone had a maximum detection of 14 μg/kg in sample B080P2. The only detection of 2-butanone was 22 μg/kg in sample B080P2. Toluene was detected in all of the samples, but was greater than the CRQL only in sample B080P4 (13 μg/kg). Volatile organic compound concentrations appear to be decreasing with depth. Because sample B080P3 was not analyzed, due to a broken sample container, no results exist for the 5 ft to 7 ft interval. Table 3-8 presents a summary of the VOC analytical results.

The semi-volatile organic compound bis(2-ethylhexyl)phthalate was detected at 800 μg/kg. No other semi-volatile compounds were detected above the CRQL of 330 μg/kg. Because sample B080P3 was not analyzed, no results exist for the 5 ft to 7 ft interval. Table 3-8 presents a summary of the semi-volatile organic compounds detected in the 116-F-4 borehole.

No pesticides or PCB were detected in the 116-F-4 borehole.

Barium was detected at 208 mg/kg in sample B080P3. No other inorganics were detected above the Hanford Site 95% UTL.

3.4.2.2 Radionuclide Analysis. Gross alpha detections ranged from 14 pCi/g in sample B080P3 to 96 pCi/g in sample B080P4. Gross beta concentrations ranged from 20 pCi/g in sample B080P2 to 4900 pCi/g in sample B080P4. The maximum concentrations were found in sample B080P4 (9.4 ft to 11.4 ft bls). Radionuclides detected above 1 pCi/g in the B080P4 sample were: potassium-40 (11 pCi/g), strontium-90 (1500 pCi/g), cesium-137 (1800 pCi/g), europium-152 (16 pCi/g), plutonium-239/240 (130 pCi/g), and americium-241 (12 pCi/g). Concentrations of radionuclides decreased with depth. The only radionuclide detected above 1 pCi/g in samples B080P9 and B080Q3 was potassium-40. Table 3-8 presents a summary of the radionuclides detected from the sampling of 116-F-4 vadose zone borehole.

3.4.2.3 Field Screening. The well site geologist performed field screening for VOC using an OVM PID. No VOC were detected during the investigation of borehole 116-F-4.

Radioactivity was monitored during drilling using a Ludlum 14C portable scintillation detector with a gross gamma probe. The gross gamma background level for the site was 1,500 cpm. The maximum gross gamma level detected during this investigation was 150,000 cpm at 11 ft to 12 ft bls. Gross gamma exceeding the site background level was found from 2 ft to 25 ft bls, which corresponds to the borehole geophysical logging results.

3.4.2.4 Geophysical Borehole Logging. The 116-F-4 borehole was logged from 0 to 24.9 ft bls. The three man-made radionuclides detected during logging were, cesium-137, europium-152, and europium-154. Cesium-137 was detected from 0 ft to 22 ft bls, with maximum calculated activities of 425 pCi/g and 2,280 pCi/g at depths of 2.5 ft and 10.5 ft bls respectively. Europium-152 was detected from 2 ft to 4 ft bls, with a maximum of 5 pCi/g at 2.5 ft. It was also detected from 6 ft to 14 ft bls, with a maximum of 20 pCi/g at 10 ft bls. Europium-154 was detected from 9 ft to 13.5 ft bls, with a maximum of 2 pCi/g at 9.5 ft.

3.4.3 Treatability Test Excavation Overview

The 100 Area Excavation Treatability Test (DOE-RL 1994c) was conducted by excavating the contaminated soil from the 116-F-4 pluto crib. Approximately 4500 yd^3 of soil was removed during the excavation. Of this material, over 500 yd^3 was designated contaminated soil. At the completion of the test the clean soil along with make-up soil was used to refill the excavation hole, and the surface was returned to grade level.

In order to ensure that the excavation removed all contamination from the crib, verification samples were taken from varying depths from the sides and base of the excavation. Soil sampling was also conducted in the clean spoil piles to ensure that the soil set aside as clean material met the applicable requirements for use as clean fill (DOE-RL 1994c).

Treatability test soil sampling indicated that the 116-F-4 pluto crib and all associated contamination has been successfully removed to levels below current guidance. Full analytical results are presented in the *100 Area Excavation Treatability Test Report* (DOE-RL 1994c).

3.4.4 Summary

The 116-F-4 data used in the Qualitative Risk Assessment of the 100-FR-1 Source Operable Unit (WHC 1993), which is summarized in Section 4 of this report, is based upon the 116-F-4 LFI borehole data and is presented in this report for information only.

Volatile organic compounds in the 116-F-4 borehole that exceeded the CRQL of 10 μg/kg were: 2-butanone, acetone, and toluene. Although these constituents are most likely attributable to sampling media or laboratory contamination the analyses were not flagged with the "B" qualifier to indicate laboratory blank contamination. Historical records do not indicate the disposal of these contaminants in the 100-FR-1 Operable Unit (DOE-RL 1992a). Bis(2-ethylhexyl)phthalate, in sample B080P2 (0 ft to 2 ft bls), at 800 μg/kg, was the only semi-volatile detected above the CRQL. Bis(2-ethylhexyl)phthalate is commonly used as a liquid in vacuum pumps (Sax and Lewis 1987), but no records indicate that it was disposed of in the 100-FR-1 Operable Unit. No analyses were performed for volatile organic and semi-volatile organic compounds for sample B080P3 (5 ft to 7 ft) because that sample was not received by the laboratory.

No pesticides or PCB were detected in the 116-F-4 borehole. The only inorganic compound detected above the Hanford Site background 95% UTL was barium in sample B080P3 (5 ft to 7 ft) at 208 mg/kg. No historical sampling data exists for organic, inorganic, or nonradionuclide constituents, therefore, a comparison is not possible.

Radionuclide contamination was detected in all samples collected from the 116-F-4 borehole. The maximum concentrations were detected in sample B080P4 (9.4 ft to 11.4 ft bls). Radionuclide contamination decreased with depth, only potassium-40 was detected above 1 pCi/g below the 13.4 ft to 15.6 ft sample interval. Field screening and borehole geophysical logs also show maximum contaminant levels in this interval. The maximum detected field screening for gross gamma was 150,000 cpm in the 11 ft to 12 ft interval. Cesium-137 was the highest detected contaminant in sample B080P4 at 1,800 pCi/g. Cesium-137 was also the maximum detected contaminant in the spectral gamma log (2283 pCi/g) at 10.5 ft.

Treatability test soil sampling indicated that the 116-F-4 Pluto Crib contamination has been successfully removed to levels below current guidance (DOE-RL 1994c).

3.4.5 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring wells 199-F5-47 and 199-F5-4 are downgradient of site 116-F-4. No monitoring well is located close enough to this site to be considered an upgradient well. In well 199-F5-47 the maximum detection of chromium was 20.7 μg/l in April of 1993. The maximum level of strontium-90 was detected in April 1993 at 3.8 pCi/l. In well 199-F5-4 the maximum detection of chromium was 19.7 μg/l in April of 1993. Strontium-90 was not detected in well 199-F5-4. Since no upgradient values were available, the impact to groundwater from the 116-F-4 site could not be determined.

3.5 116-F-6 LIQUID WASTE DISPOSAL TRENCH

The 116-F-6 liquid waste disposal trench is an inactive liquid waste site that operated from 1952 to 1965. The trench is 90 m (300 ft) long, 30 m (100 ft) wide, and 3 m (10 ft) deep and is oriented north-south approximately 55 m (180 ft) southeast of the 105-F Reactor building. The trench received cooling water while maintenance and repairs were being performed on the effluent system. This trench was also used during several reactor upgrades. In 1956, effluent water overflowed, flooding an area south of the site. This area was later released from radiological control (DOE-RL 1992a).

The trench has been backfilled with 3.0 m to 3.7 m (10 to 12 ft) of added soil, and today appears as a large, unfenced cobble-covered field with little vegetation growing. The site is within a large zone of permanent concrete monuments with "Underground Radioactive Material" warning signs. No vent pipes or other accessories are evident. The waste site has recently been extended to the east by erecting a light-weight chain fence with warning signs due to the exceedance of allowable surface radioactivity levels. The extension is approximately 7.6 x 122 m (25 x 400 ft) and has not been stabilized in the same manner as the original site (Deford 1993).

116-F-6 received an estimated 100,000 l of liquid waste. In addition to radioactive contamination 3,000 kg of sulfamic acid were reportedly disposed into this unit.

Figure 3-1 shows the location of the 116-F-6 site and the approximate location of the vadose zone borehole. Figure 3-12 is a summary diagram of the LFI borehole data.

3.5.1 Geology

This site is characterized by sandy gravel to 26 ft bls (total depth of borehole). The site is reported to have been backfilled with 10 ft to 12 ft of soil (DOE-RL 1992a), however, the well site geologist found no discernable characteristics between the fill and native soils that indicated the contact.

3.5.2 116-F-6 Borehole Soil Samples

Borehole 116-F-6 was drilled to a total depth of 26 ft bls. Five soil samples were collected and submitted for chemical and radionuclide analysis. Samples collected were: from B080L9 (0 to 2 ft bls), B080M0 (6.5 to 8.5 ft bls), B080M1 (9 ft to 11 ft bls), B080M2 (15 ft to 17 ft bls), and B080M3 (19 ft to 21 ft bls).

3.5.2.1 Chemical Analysis. The VOC detected in borehole 116-F-6 were acetone, benzene, methylene chloride, and toluene. The maximum detection for acetone was in sample B080M3 (15 μg/kg). The maximum detection of toluene was 12 μg/kg in sample B080M1. Acetone and toluene were the only VOC that were detected above the CRQL. Table 3-9 presents the detected VOC in 116-F-6.

The semi-volatile organic compound di-n-butylphthalate was detected at 140 μg/kg in sample B080M1. Bis(2-ethylhexyl)phthalate was detected at 72 μg/kg in sample B080M2. No other semi-volatile organic compounds were detected. No semi-volatile compounds were detected above the CRQL. Table 3-9 presents a summary of the semi-volatile organic compounds detected in the 116-F-6 borehole.

Chromium, in sample B080M0 (30.2 mg/kg), and zinc in sample B080M0 (106 mg/kg) were detected above the Hanford Site background 95% UTL. Table 3-9 presents the detections in the LFI of 116-F-6.

3.5.2.2 Radionuclide Analysis. Table 3-9 summarizes the radionuclide concentrations. Gross beta ranged from 14 pCi/g in sample B080L9 to 350 pCi/g in sample B080M0. The maximum concentrations of radionuclides occurred in sample B080M0. The radionuclides that were detected above 1 pCi/g in that sample were: potassium-40, cobalt-60, strontium-90, cesium-137, europium-152, europium-154, and plutonium-239/240. Cesium-137 (230 pCi/g) and europium-152 (190 pCi/g) were the largest radionuclide concentrations detected.

3.5.2.3 Field Screening. Volatile organic compounds were monitored by the well site geologist using an OVM PID. No VOC were detected above the action level of 5 ppm during the drilling of borehole 116-F-6.

Radioactivity was monitored during drilling using a Ludlum 14C portable scintillation detector with a gross gamma probe. The gross gamma background level for the site was 1,690 cpm. The maximum gross gamma level detected during this investigation was 21,000 cpm at 8 ft to 9 ft bls. Gross gamma levels exceeding site background were detected from 6.5 ft to 13 ft bls. No beta readings exceeded the site background of 65 cpm.

The well site geologist also performed an analysis for hexavalent chromium on the soil from 25 ft bls. No chromium was detected.

3.5.2.4 Geophysical Borehole Logging. The 116-F-6 borehole was monitored from 0 ft to 13.5 ft and from 15 ft to 23 ft bls. The maximum calculated activity for all of the man-made radionuclides detected was found at 6.5 ft bls. The man-made radionuclides detected were, cobalt-60, cesium-137, europium-152, and europium-154. Cesium-137 was detected from

5 ft to 15 ft bls, with a maximum calculated activity of 74 pCi/g. Cobalt-60 was detected from 4.5 ft to 10 ft bls, with a maximum calculated activity of 18 pCi/g. Europium-152 was detected from 4 ft to 16 ft bls, with a maximum of 169 pCi/g. Europium-154 was detected from 4.5 ft to 10 ft bls, with a maximum of 20 pCi/g.

3.5.3 Summary

Acetone was detected in low concentrations in three samples in excess of the CRQL with a maximum concentration of 15 μg/kg in the 19 ft to 21 ft sample. Toluene was also detected in excess of the CRQL in one sample at 12 μg/kg. No historical records indicate that acetone or toluene were disposed of in the 100-FR-1 Operable Unit. Although these contaminants are most likely attributable to sampling media or lab contamination, the analyses were not flagged with the "B" qualifier to indicate laboratory blank contamination. Benzene and methylene chloride were also detected but were far below the CRQL. No semivolatiles were detected in excess of the CRQL. No pesticides or PCB were detected. Chromium and zinc were detected above the Hanford Site background 95% UTL at 30.2 mg/kg and 106 mg/kg respectively. Historical data for organic, inorganic, and nonradionuclide constituents are not available for comparison.

The maximum radionuclide contamination for 116-F-6 was found in sample B080M0 (6.5 ft to 8.5 ft bls) in what was reported to be fill material. The maximum gross beta measurement (350 pCi/g) was detected in this interval. Cesium-137 and europium-152 were the highest detected values in this interval at 230 pCi/g and 190 pCi/g respectively. Geophysical logs for the 116-F-6 borehole also revealed maximum values for man-made radionuclides at 6.5 ft, the highest of which being europium-152 at 169 pCi/g. The geophysical logs detected radionuclides from 4 ft to 16 ft bls. Field screening results showed gross gamma readings at 6.5 ft of 6,500 cpm increasing to 21,000 cpm at 8 ft to 9 ft bls. Field screening showed gross gamma levels that exceeded the site background from 6.5 ft to 13 ft bls.

Dorian and Richards (1978) reports the results of soil samples collected from four sites in the 116-F-6 trench. The maximum concentrations for the historical sampling was found in soil boring "A" at 7.5 ft. Radionuclides detected were: tritium, uranium, cobalt-60, strontium-90, cesium-137, europium-152, europium-154, europium-155, plutonium-238, and plutonium-239/240. Radionuclide concentrations showed a decrease with increased depth. Analytical results and soil boring locations are presented in Appendix A.

3.5.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F8-2 is upgradient, and monitoring well 199-F5-47 is downgradient of site 116-F-6. Chromium values in the upgradient well were not appreciably different from those values found in the downgradient well. The maximum strontium-90 concentration in upgradient well 199-F8-2 was 41 pCi/l, and the maximum concentration in the downgradient well 199-F5-47 was 3.8 pCi/l. It does not appear that the 116-F-6 trench is currently impacting groundwater.

3.6 116-F-9 PNL ANIMAL WASTE LEACH TRENCH

The animal waste leach trench is located 46 m (150 ft) northeast of the 116-F-14 retention basin. The site consists of two trenches joined to form a "Y" shape. The longer leg measures 120 m (400 ft) by 5 m (15 ft) by 3 m (10 ft) deep and the shorter section is 30 m (100 ft) long and of similar width and depth. 116-F-9 received waste water from the cleaning of animal pens in the EAF from 1963 to 1976 (DOE-RL 1992a).

The trench appears today as a cobble-covered, open field, immediately northeast of the 107-F retention basin. The trench is unfenced and has no unique identifying markers. It resides within a larger area identified by permanent concrete markers and the "Underground Radioactive Material" warning signs (Deford 1993).

The animal waste leach trench received an estimated 300,000,000 l of liquid waste. This unit contains radiological contamination from EAF activities (Stenner et al. 1988).

Figure 3-2 shows the location of the animal waste leach trench and the approximate location of the vadose zone borehole at the north end of this unit.

3.6.1 Geology

116-F-9 is covered by approximately 9 ft of fill material, the 0 to 8 ft bls interval being sandy gravel, and 8 to 9 ft bls being silty sandy gravel. The 9 to 21 ft bls interval is sandy gravel. Soils in the 21 to 25 ft bls interval are composed of gravelly sand. Sandy gravel makes up the soil found between 25 and 26.8 ft bls (total depth of borehole).

3.6.2 116-F-9C Borehole Soil Samples

Five soil samples were collected and submitted for chemical and radionuclide analysis from the 116-F-9C vadose zone borehole. The samples were B080N5 (2.5 ft to 4.5 ft bls), B080N6 (9 ft to 11 ft bls), B080N7 (14.5 ft to 16.5 ft bls), B080N8 (16.5 to 18.5 ft bls), and B080P0 (23 ft to 25 ft bls). Sample B080N5 was taken from 2.5 ft to 4.5 ft bls due to poor sample recovery in the 0 ft to 2 ft bls interval. Figure 3-13 is a summary diagram of the 116-F-9C LFI data.

3.6.2.1 Chemical Analysis. The VOC detected equal to or greater than the CRQL were: toluene in samples B080N5 and B080N6 (10 μg/kg), acetone in samples B080N6, B080N8 and B080P0 (11, 11, and 12 μg/kg), and 2-butanone in sample B080P0 (23 μg/kg). Table 3-10 presents a summary of the VOC detected.

Di-n-butylphthalate was the only semi-volatile organic compound detected. The concentration was 74 µg/kg in sample B080P0. No semi-volatile was detected above the CRQL of 330 µg/kg.

Alpha-chlordane and gamma-chlordane exceed the CRQL in two samples, with maximum values of 4.7 and 4.8 µg/kg, respectively, in sample B080N6. Table 3-10 presents a summary of the detected pesticides and PCB.

No metals or other inorganic compounds were detected in concentrations above the Hanford Site 95% UTL at the 116-F-9C borehole.

3.6.2.2 Radionuclide Analysis. No gross alpha was detected in any of the samples analyzed. Gross beta levels ranged from 11 pCi/g in sample B080N5 to 52 pCi/g in sample B080N6. The radionuclides that were detected above 1 pCi/g in the 116-F-9C borehole were: carbon-14, potassium-40, and strontium-90. Strontium-90 values ranged from 15 pCi/g to 19 pCi/g in the 9 ft to 25 ft bls interval. Carbon-14 values ranged from 120 pCi/g to 140 pCi/g in the 0 ft to 11 ft bls interval. Table 3-10 presents a summary of the radionuclides detected at the 116-F-9C borehole.

3.6.2.3 Field screening. Volatile organic compounds were monitored by the well site geologist using an OVM PID. No VOC were detected above the action level of 5 ppm during the drilling of borehole 116-F-9C.

Radioactivity was monitored during drilling using a Ludlum 14C portable scintillation detector with a gross gamma probe. The gross gamma background level for the site was 1,800 cpm. The gross gamma background was exceeded at 9 ft bls (2,000 cpm) and at 13.5 ft bls (2,100 cpm). The beta site background was 65 cpm which was exceeded from 4 ft bls to 16 ft bls. The maximum beta reading during the investigation was 100 cpm.

The well site geologist also performed an analysis for hexavalent chromium on the soil from 25 ft bls. No chromium was detected.

3.6.2.4 Geophysical Borehole Logging. The 116-F-9C borehole was logged from 0 ft to 24 ft bls. Trace amounts of cesium-137 were detected (0.3 pCi/g) at 17 ft bls. The cesium-137 observed concentrations were near the limit of the system sensitivity for low level activity at 17 ft bls. No other man-made radionuclides were observed.

3.6.3 116-F-9D Test Pit Soil Samples

Four soil samples were collected in the 116-F-9D test pit and submitted for chemical and radionuclide analysis. The samples were B08G78 (0 ft to 1 ft bls), B08G79 (9 ft to 10 ft bls), B08G80 (15 ft bls), and B08G81 (20 ft bls) total depth of test pit. Figure 3-14 is a summary diagram of the 116-F-9D test pit.

3.6.3.1 Chemical Analysis. Volatile organic compounds that were detected in excess of the CRQL were: 4-methyl-2-pentanone, acetone, and toluene. The maximum values for acetone and toluene were found in sample B08G79 at 66 μg/kg and 87 μg/kg, respectively. 4-methyl-2-pentanone was detected in sample B08G79 at 13 μg/kg. Table 3-11 presents a summary of the detected volatile organic compounds.

Bis(2-ethylhexyl)phthalate detected in sample B08G78 (340 μg/kg) was the only semi-volatile organic compound detected above the CRQL (330 μg/kg). Table 3-11 presents all of the detected semi-volatiles.

The maximum detections of alpha-chlordane and gamma-chlordane were found in sample B08G79 at 330 μg/kg and 200 μg/kg. No other pesticides or PCB were detected in the 116-F-9D test pit. Table 3-11 presents a summary of the detections.

Copper, silver, and zinc detected in sample B08G79 were all above the Hanford Site background 95% UTL at values of 32.5 mg/kg, 7.9 mg/kg, and 246 mg/kg, respectively. No inorganics were detected above the 95% UTL in any of the other samples. Table 3-11 summarizes the detected inorganics.

3.6.3.2 Radionuclide Analysis. The radionuclides detected were: potassium-40, cobalt-60, strontium-90, cesium-137, europium-152, radium-226, thorium-228, thorium-232, uranium-233/234, uranium-238, and plutonium-239/240. The maximum gross alpha detection was 8.6 pCi/g in sample B08G78. The maximum gross beta detected was in sample B08G79 at 100 pCi/g. Only potassium-40 and strontium-90 concentrations exceeded 1.1 pCi/g. The maximum strontium-90 concentration, 39 pCi/g, occurred in the 9 ft to 10 ft interval. The concentrations of potassium-40 ranged from 13 to 15 pCi/g (Table 3-13).

3.6.3.3 Field Screening. No VOC were detected above the action level (5 ppm) during the 116-F-9D test pit investigation.

Field screening of radioactivity was performed by the well site geologist. The site gross gamma background was 75 cpm. The maximum reading for the test pit 116-F-9D was 400 cpm at the 9 ft to 10 ft bls interval. Readings exceeding site background were recorded only at this interval.

The well site geologist also performed field screening for hexavalent chromium on soils from 17 ft bls. Hexavalent chromium concentration was < 10 ppm.

3.6.4 Summary

Volatile organic compounds detected at or above the CRQL in 116-F-9C borehole were: 2-butanone (23 μg/kg), acetone (12 μg/kg), and toluene (10 μg/kg). The VOC maximum detected values in the 116-F-9D test pit were: acetone (66 μg/kg), 4-ethyl-2-pentanone (13 μg/kg), and toluene (87 μg/kg). Field screening for VOC did not detect any values greater than the action level (5 ppm). Bis(2-ethylhexyl)phthalate was the only semi-volatile organic compound detected above the CRQL (330 μg/kg) in the 116-F-9D test pit at 340 μg/kg. No semi-volatiles were detected above the CRQL in the 116-F-9C borehole.

Alpha-chlordane and gamma-chlordane were detected in both 116-F-9C and 116-F-9D. The maximum values for these two constituents were found in the 116-F-9D test pit. No other pesticide or PCB was detected.

Copper, silver, and zinc were all detected above the Hanford Site background 95% UTL in the 116-F-9D test pit. All of the inorganic contamination was detected in the 9 ft to 10 ft bls sample. Historical data for organic, inorganic, and nonradionuclide constituents are not available for comparison.

The maximum radionuclide contamination for both the borehole and test pit investigated for the LFI occurred in the 9 ft to 10 ft bls interval. Potassium-40 and strontium-90 were detected in all of the samples and were the only radionuclides detected above 1 pCi/g with the exception of carbon-14 in 116-F-9C. Geophysical borehole logging of 116-F-9C showed only trace amounts of cesium-137 at 17 ft bls. Field screening at both sites investigated showed maximum readings in the 9 ft to 13.5 ft bls interval.

Dorian and Richards (1978) provides no soil sample information on this waste site because it was still in use in 1976. Six samples were taken to a maximum depth of 30 ft bls in August 1979 and are reported in a memo from V.R. Richards to J.J. Dorian dated August 10, 1981 (Deford 1993). The historical data shows the maximum contamination at 22.5 ft bls. The radionuclides detected at this depth were: cobalt-60, strontium-90, cesium-137, europium-152, europium-154, europium-155, and plutonium-239/240. The highest radionuclide detected was strontium-90 at 22.5 ft bls. No contamination was detected above 15 ft bls. Contamination generally decreased with depth. A complete reporting of this data and soil boring locations are presented in Appendix A.

3.6.5 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-46 is upgradient of site 116-F-9. Monitoring well 199-F5-43A is downgradient of site 116-F-9. The maximum chromium concentration in well 199-F5-46 was 303 μg/l in the December 1992 sample. The highest detected strontium-0 concentration in well 199-F5-46 was 13 μg/l in April 1993. The maximum concentration of chromium in well 199-F5-43A was detected in January of 1993 at 12.8 μg/l. The maximum concentration of strontium-90 in well 199-F5-43A was 2.7 μg/l in both January and April of 1993. Since the values for both constituents are considerably higher in the upgradient well, it appears that the 116-F-9 site is not currently impacting groundwater.

3.7 116-F-14 RETENTION BASIN

The 116-F-14 (107-F) retention basin is an inactive liquid waste site that served as an integral component of the F Reactor cooling system. It is a 137 m (450 ft) by 70 m (230 ft) by 7.3 m (24 ft) deep reinforced concrete basin that is divided lengthwise into two chambers. The retention basin operated from 1945 to 1965, it received essentially all reactor cooling water passing from the reactor to the Columbia River. The retention basin held water for a brief period of time, allowing radioactive decay and thermal cooling to occur before the water went into the Columbia River. The total volume of water has not been calculated, but the flow rate ranged between 41,000 and 78,000 gpm (Deford 1993). Cooling water flowed from the reactor into the south end of the basin through one of three large pipelines that operated during different time periods. Water flowed from the north end of the basin through a concrete pipe to the 116-F-8 outfall structure from which it flowed into the river. In addition, there is a narrow ditch that extends from the northeast corner of the retention basin eastward to the Columbia River shoreline. This ditch, identified as the basin leak ditch, is approximately 152 m (500 ft) long. The ditch was first used when a major release, in May 1955, flooded the area around the basin. The water drained to the Columbia River via the basin leak ditch (Selby and Soldat 1958). This ditch later received effluent that overflowed from a manhole located near the north end of the basin. An incident report describes the release of effluent through the manhole, which apparently occurred on an intermittent basis for an extended period of time before it was repaired (Heid 1956).

As early as September 1945, effluent springs began to appear along the riverbank in association with retention basin leakage. At least 30 springs were identified along the shoreline extending above and below the outfall structure for approximately 244 and 457 m (800 and 1,500 ft), respectively (Healy 1945). Sampling of the water from these springs was performed several times between October and November 1945 for thermal and gross radiological characterization. This testing reported temperatures ranging from 14°C to 37°C (57°F to 99°F) and concentrations of $<2 \times 10^{-5}$ to 7.3×10^{-4} μg/l, but it is not known what these concentrations refer to. For comparison, effluent from the basin was also sampled during this period, with a concentration of 0.2 μg/l and a temperature of 38°C (100°F) reported. The highest observed temperatures and concentrations were reported in samples collected in the immediate vicinity of the outfall structure. An examination of the riverbank in 1984 found only two remaining springs, at the river water intake and the eastern boundary of the 100 F Area (DOE-RL 1992a).

Shortly after the reactor was shut down in 1965, water within the basin was pumped to the 116-F-2 overflow trench via the EM bypass ditch, several feet of fill material was placed over the remaining basin sludge for stabilization, and the basin walls were spray coated with asphalt (DOE-RL 1992a). In 1987, the retention basin and associated ancillary piping were decommissioned. This effort resulted in the demolition of the concrete walls, with subsequent placement of this material and approximately 460 m (1,500 ft) of the 152-cm (60-in) diameter effluent pipe within the basin footprint. The site was then partially backfilled and covered with a soil cap.

Known leakage from the 116-F-14 basin appears to have occurred primarily along the south and west sides (Dorian and Richards 1978). Estimates of leakage rates are not well documented, but the presence of a groundwater mound beneath the basin extending as high as 3 m (10 ft) above the pre-existing water table elevation (Brown 1963) suggests that significant leakage was occurring during this time.

Figure 3-2 shows the location of the 116-F-14 retention basin and the approximate location of the vadose zone borehole in the southern portion of the basin. Figure 3-15 is a summary diagram of the LFI borehole data.

3.7.1 Geology

The 116-F-14 borehole is characterized by sandy gravel fill to a depth of 3 ft bls, with an increased silt content (10%) in the 2.7 to 3 ft bls interval. The concrete liner was encountered from 3 to 5 ft bls, and was reported to be poorly cemented, crumbly, and moist. Soils in the 5 to 23 ft bls interval consist of sandy gravel (50% sand, 50% gravel). The 23 to 26.6 ft interval bls (total depth of borehole) is composed of gravelly sand (30% gravel, 70% sand).

3.7.2 116-F-14 Borehole Soil Samples

Six soil samples were submitted for chemical and radionuclide analysis from the 116-F-14 borehole: B080Q4 (0 ft to 2 ft bls), B080Q5 (2.5 ft to 5 ft bls), B080Q6 (5 ft to 7 ft bls), B080Q7 (10.5 ft to 13 ft bls), B080Q8 (16.6 ft to 18.6 ft bls), B080Q9 (23 ft to 24.5 ft bls). Four soil samples were collected for physical properties analysis: B08734 (13 ft to 15.5 ft bls), B08735 (16.6 ft to 18.6 ft bls), B08736 (20.3 ft to 22.9 ft bls), and B08737 (23 ft to 24.5 ft bls).

3.7.2.1 Chemical Analysis. Volatile organic compounds detected above the CRQL were, acetone and toluene. Acetone had a maximum detection of 46 μg/kg in sample B080Q8. Toluene had a maximum detection of 82 μg/kg in sample B080Q5, and was detected in all samples. Table 3-12 presents a summary of the detected VOC.

The concentrations of diethylphthalate at 2,600 μg/kg in sample B080Q9 and di-n-utylphthalate at 340 μg/kg in sample B080Q4 were the only semi-volatiles that were detected above the CRQL (330). Table 3-12 summarizes the detected semi-volatile organic analysis.

No pesticides or PCB were detected.

The inorganic compounds that were detected above the Hanford Site 95% UTL were: cadmium, copper, chromium, and zinc. Cadmium, copper, and zinc concentrations in sample B080Q6 were 1.5, 29.3, 87.4 mg/kg respectively. Chromium was detected in samples B080Q6, B080Q7, B080Q8, and B080Q9, with a maximum concentration of 124 mg/kg in sample B080Q6. Sample B080Q6 had the largest concentrations of inorganic contaminants. Table 3-12 presents a summary of the detected inorganic compounds.

3.7.2.2 Radionuclide Analysis. Gross alpha was detected only in sample B080Q5 at 14 pCi/g. Gross beta was detected in all six soil samples with a maximum concentration of 440 pCi/g in sample B080Q5. With the exception of uranium, the maximum concentrations occur in the concrete liner 2.5 ft to 5 ft interval (B080Q5). Table 3-14 presents a summary of the radionuclides detected in the 116-F-14 borehole.

3.7.2.3 Field Screening. Field screening of VOC performed by the well site geologist yielded no readings of greater than the action level (5 ppm).

Field screening of radioactivity was performed by the well site geologist. Site background for gross gamma was 2,800 cpm. The highest detected levels were in the 2.5 ft to 5 ft bls interval with a maximum reading of 25,000 cpm. The beta background of 400 cpm was exceeded in the 2.5 ft to 5 ft bls interval at 500 to 600 cpm.

Hexavalent chromium field screening was performed by the well site geologist on soils from 26.6 ft interval. No chromium was detected.

3.7.2.4 Geophysical Borehole Logging. The 116-F-14 borehole was logged from 0 ft to 23 ft bls. Man-made radionuclides identified during the spectral gamma-ray survey were cobalt-60, cesium-137, europium-152, and europium-154. Cesium-137 was detected from 4.5 to 23.5 ft bls, with the maximum calculated activity of 5 pCi/g from 6.5 ft to 7.5 ft bls. Cobalt-60 was detected from 0.5 ft to 9.5 ft bls, with the maximum calculated activity of 31 pCi/g at 4 ft bls. Europium-152 was detected from 0.5 ft to 13 ft bls, with the maximum calculated activity of 730 pCi/g at 4 ft bls. Europium-154 was detected from 0 ft to 12.5 ft bls, with the maximum calculated activity of 92 pCi/g at 4 ft bls.

3.7.3 Physical Properties Samples

Four samples were taken in conjunction with the 116-F-14 borehole investigation for physical properties analysis. Split tube samples were collected from borehole 116-F-14 at 13.5 to 15.5 ft, 17.1 to 17.6 ft, 20.3 to 22.9 ft, and 23.5 to 24 ft bls. The first three samples are described by the well site geologist as moist, sandy gravel. The fourth sample was taken in sediments described as dry, gravelly sand. All four samples were collected in the vadose zone. Due to the difficulty of collecting samples of the coarse-grained materials, the physical properties are biased toward finer-grained soils.

3.7.3.1 Discussion of Physical Properties. Laboratory sieve analysis showed that the sediment grain size in the 13.5 to 15.5 ft bls interval consisted of 0% gravel, 83% sand, and 17% silt and clay. The soil grain size in the 17.1 to 17.6 ft bls interval consisted of 59% gravel, 38% sand, and 3% silt and clay. The soil grain size in the 20.3 to 22.9 ft interval bls consisted of 0% gravel, 77% sand, and 23% silt and clay. In the 23.5 to 24 ft bls interval the soil grain size consisted of 51% gravel, 44.38% sand, and 4.62% silt and clay. The specific gravity (sG) was determined for both course and fine fraction of the samples. The average sG for the four sample intervals was 2.73. The results for the various tests listed below are shown in order of increasing depth.

- bulk density: 2.14 g/cc, 2.13 g/cc, 2.17 g/cc, and 2.16 g/cc
- moisture content: 2.93%, 2.6%, 2.71%, not analyzed

- porosity: 25.87%, 13%, 23.41%, 28%

- hydraulic conductivity: 3.79e-02 cm/sec, 3.3e-02 cm/sec, 1.26e-03 cm/sec, 1.62e-04 cm/sec.

3.7.4 Summary

Volatile organic compounds that were detected above the CRQL (10 μg/kg) were acetone and toluene. Both constituents were detected in all of the samples. The maximum detection of toluene was 82 μg/kg in the 2.5 ft to 5 ft sample. The maximum detection of acetone was 46 μg/kg in the 16.6 to 18.6 sample. Field screening for VOC yielded no values greater than the 5 ppm action level. Di-n-butylphthalate and diethylphthalate were detected above the CRQL (330 μg/kg) at 340 μg/kg (B080Q4) and 2,600 μg/kg (B080Q9), respectively. No other semi-volatiles were detected above the CRQL. The origin of the organic compounds is unknown. There is no historical record of these constituents being used in the reactor effluent. No pesticides or PCB were detected during the 116-F-14 LFI.

Inorganic compounds cadmium, chromium, copper, and zinc were detected above the Hanford Site background 95% UTL. Cadmium, copper, and zinc were all detected in the 5 ft to 7 ft bls sample. Chromium contamination was detected from 10.5 ft to 24.5 ft bls, with the maximum detection in the 10.5 ft to 13 ft bls sample.

Radionuclides detected above 1 pCi/g in the 116-F-14 borehole include: carbon-14, cobalt-60, strontium-90, cesium-137, europium-152, europium-154, europium-155, plutonium-239/240, and americium-241. With the exception of uranium, the maximum concentrations occur in the concrete liner in sample B080Q5 (2.5 ft to 5 ft bls). The radionuclides with the highest detections were europium-152 (940 pCi/g) and europium-154 (130 pCi/g). The only gross alpha value was in the 2.5 ft to 5 ft bls sample at 14 pCi/g. The maximum gross beta concentration was in the 2.5 ft to 5 ft bls sample at 440 pCi/g. Radionuclide values decreased with depth.

Dorian and Richards (1978) sampled thirty-two sample holes in and around the 116-F-14 retention basin. Sludge within the retention basin contained the highest radionuclide concentrations, but only accounted for about 50% of the total radionuclide inventory, because of relatively large volumes of contaminated soil beneath and around the basin. Three sample holes drilled through the retention basin indicate that the majority of contamination under the basin is confined to within 5 ft of the basin floor. Radionuclides detected in samples taken inside the retention basin were: tritium, uranium, cobalt-60, nickel-63, strontium-90, cesium-134, cesium-137, europium-152, europium-154, europium-155, plutonium-239/240, and americium-241. The Dorian and Richards (1978) radionuclide concentrations were typically higher than those found in the LFI. Radionuclide concentrations of selected samples from test holes drilled at the retention basin, and of samples taken of soil fill and sludge at the backhoe sampling locations are presented in Appendix A.

Four sites, analogous to the 116-F-14 site and located in other source operable units have been examined thus far by LFI. These are 116-C-5, 116-D-7, 116-DR-9, and 116-H-7. To assess the concept that these sites are analogous, a comparison of radionuclide and chemical analytical results from the LFI samples was performed. Chromium was detected in all of the analogous sites. Cadmium and copper were only detected in one other analogous site. Little similarity could be found for VOC, semi-volatiles, and no pesticides or PCB were detected with the exception of aroclor-1260 at site 116-DR-9. Radionuclides detected in the analogous sites are similar to those at the 116-F-14. Table 3-13 presents a comparison of the maximum detected constituents in the analogous facilities.

3.7.5 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-46 is upgradient of site 116-F-14. Monitoring well 199-F5-3 is downgradient of site 116-F-14. The maximum chromium concentration in well 199-F5-46 was 303 μg/l in the December 1992 sample. The maximum concentration of strontium-90 was 2.7 in both January and April of 1993. The only chromium value detected in well 199-F5-3 was 30.6 μg/l in April of 1993. The maximum concentration of strontium-90 was 250 pCi/l in January 1993. Since the strontium-90 values are considerably higher in the downgradient well, it appears that the 116-F-14 site is currently impacting groundwater.

3.8 108-F FRENCH DRAIN

The 108-F french drain is located on the east side of the 108-F biology building. Dates of operation for this unit are unknown. The drain is constructed of a 30 inch steel pipe of unknown length. It is buried to a depth that places its upper surface a few inches above grade. It has a steel lid and is gravel filled (Deford 1993). This site received condensate from laboratory hoods inside 108-F that were possibly contaminated with plutonium-239 and beta emitting isotopes (Ruppert 1953).

Figure 3-1 shows the location of the 108-F french drain and associated hand sampling location investigated for this LFI.

3.8.1 Geology

Limited field investigation activities at the 108-F french drain consisted of one hand sampling excavation where two soil samples were taken from 1 to 1.5 ft and from 3.5 to 4.5 ft bls. There is no geologic description from this LFI activity but it is assumed that the soils are composed of sands and gravels similar to that encountered at other waste sites.

3.8.2 108-F Soil Samples

Two soil samples were collected and submitted for chemical and radiological analysis from hand sampling the 108-F french drain, the surface sample B080R4 (0 ft to 1 ft bls), and B080R5 (3.5 ft to 4.5 ft bls).

3.8.2.1 Chemical Analysis. Toluene was above the CRQL (10 μg/kg) in B080R4 and B080R5 at 86 μg/kg and 480 μg/kg. No other VOC were detected. Table 3-14 presents a summary of the detected volatiles.

Semi-volatile compound bis(2-ethylhexyl)phthalate was detected in excess of the CRQL in both samples at 4,100 μg/kg and 580 μg/kg. The next highest maximum value was benzo(a)anthracene at 62 μg/kg. Table 3-14 summarizes the semi-volatiles detected.

Polychlorinated biphenyl aroclors-1254 and -1260 were detected in sample B080R5 at 240 and 150 μg/kg and in sample B080R4 at 1,600 and 720 μg/kg, respectively. The CRQL for these constituents is 33 μg/kg. Table 3-14 presents a summary of the detected pesticides and PCB.

Chromium, copper, lead, and zinc were all detected above the Hanford Site background 95% UTL in both samples. The maximum detection of chromium was 164 mg/kg in sample B080R4. The maximum detected copper was in sample B080R4 at 73.8 mg/kg. The maximum detection of lead was 129 mg/kg in sample B080R4. The maximum detection of zinc was 79.7 mg/kg in sample B080R5. Table 3-14 presents a summary of the detected inorganic compounds.

3.8.2.2 Radionuclide Analysis. The maximum gross alpha detected was in sample B080R4 at 250 pCi/g. Gross beta was only detected in sample B080R5 (13 pCi/g). The radionuclides detected above 1 pCi/g were: potassium-40, cesium-137, plutonium-238, plutonium-239/240, and americium-241. The maximum radionuclides detected were plutonium-238 (220 pCi/g) and plutonium-239/240 (34 pCi/g) in sample B080R4. The values for plutonium-238 and plutonium-239/240 in sample B080R5 were 66 pCi/g and 11 pCi/g respectively. Table 3-14 summarizes the detected radionuclide concentrations.

3.8.2.3 Field Screening. No VOC or radionuclides were detected with field instruments during the hand sampling of the 108-F french drain.

3.8.3 Summary

Toluene and bis(2-ethylhexyl)phthalate were detected in excess of the CRQL. No other organics were detected above the CRQL. No historical records indicate the use of these constituents 108-F Laboratory. Polychlorinated biphenyl aroclors-1254 and -1260 were detected in the 0 ft to 1 ft bls sample at 1,600 μg/kg and 720 μg/kg.

Inorganic compounds detected above the Hanford Site background 95% UTL were: chromium, copper, lead, and zinc. The maximum detections of chromium, copper, and lead were found in the surface sample. The maximum detection of zinc was found in the 3.5 ft to 4.5 ft bls sample.

Radionuclides detected in the hand sampling of the 108-F french drain include: potassium-40, cesium-137, plutonium-238, plutonium-239/240, and americium-241. The highest gross alpha value was in the surface sample at 250 pCi/g. The highest radionuclides detected in the surface sample were plutonium-238 and plutonium-239/240. Gross beta was only detected in the 3.5 ft to 4.5 ft bls sample. No historical sampling data was available for comparison. No analogous sites were sampled.

3.8.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-4 is upgradient of the 108-F french drain. Monitoring well 199-F5-45 is downgradient of the 108-F french drain. The maximum chromium concentration in well 199-F5-4 was 21.1 μg/l in the December 1992 sample. Strontium-90 was not detected in well 199-F5-4. The maximum chromium value detected in well 199-F5-45 was 7 μg/l in March of 1993. The maximum concentration of strontium-90 was 1.6 pCi/l in March 1993. The slight increase in strontium-90 from the upgradient well to the downgradient well could possibly indicate that the 108-F french drain is impacting groundwater, but further investigation would be in order to accurately determine this site's impact on the groundwater.

3.9 116-F-5 BALL WASHER CRIB

The 116-F-5 Ball Washer Crib is an inactive waste site that received liquid waste containing nitric acid derived from the decontamination of boron steel balls. Dates of operation for this unit are unknown. The crib measures 3 m by 3 m by 3 m (10 ft by 10 ft by 10 ft) and is located 250 ft southwest of the 105-F building. The site reportedly received 3,000 l of liquid waste. The crib has been fully backfilled and appears today as an unmarked, gravel-covered field. It is defined by four concrete monuments with "Underground Radioactive Contamination" warning signs (Deford 1993). Figure 3-3 shows the location of 116-F-5.

3.9.1 Geology

The 100-FR-1 LFI did not include a field investigation of the 116-F-5 Crib. It is assumed that the crib is underlain by sediments similar to that found in the 116-F-4 vadose zone borehole.

3.9.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the 116-F-5 site, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.9.3 Summary

Dorian and Richards (1978) detected radionuclides strontium-90, cesium-137, europium-154, and europium-155 in one sample taken at the 116-F-5 site at 10 ft bls. All values detected in the investigation were < 1 pCi/g. The results of the analysis and soil boring locations are presented in Appendix A. No analogous sites from other 100 Area operable units have been investigated for comparison.

3.9.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-47 is downgradient of site 116-F-5. No monitoring well is located close enough to this site to be considered an upgradient well. In well 199-F5-47 the maximum detection of chromium was 20.7 μg/l in April of 1993. The maximum level of strontium-90 was detected in April 1993 at 3.8 pCi/l. No comparison between upgradient values and downgradient values was possible, however, based upon vertical extent of contamination it appears that this site 116-F-5 is not currently impacting groundwater.

3.10 116-F-8 OUTFALL STRUCTURE

The 116-F-8 outfall structure and river discharge lines served to dispose of cooling water effluent from the 116-F-14 retention basin to the Columbia River for final disposal. The outfall structure also provided overflow capability in case the outfall lines became plugged. The outfall structure was an open, reinforced concrete structure that directed water through either the river discharge lines or through the spillway. The river discharge lines consisted of two 107 cm (42 in) diameter steel pipes extending from the outfall structure approximately 137 m (450 ft) into the river. The concrete outfall structure measured 8 m (27 ft) by 4 m (14 ft) by 8 m (26 ft) deep, 7.5 m (26 ft) of which are below grade. The spillway was also of concrete and was about 61 m (200 ft) by 4.5 m (15 ft) with .6 m (2 ft) high side walls (DOE-RL 1992a).

In 1984, an inspection of this system reported that 15 to 38 m (50 to 125 ft) of both of the discharge lines had been dislodged and carried away by river current. Efforts to locate these sections were unsuccessful (Beckstrom and Steffes 1986). Currently the outfall structure appears as an earthen mound. The portion of the outfall structure that extended above grade is demolished into the cavity and the entire structure covered with clean soil. The upper portion of the spillway appears to have been demolished and covered with clean soil. About 7.5 m (25 ft) of the lower portion of the spillway is intact and exposed.

No radionuclide or hazardous chemical inventory has been calculated for this waste site. Figure 3-3 shows the location of the 116-F-8 Outfall Structure.

3.10.1 Geology

No site-specific geologic data are available for the 116-F-8 outfall structure.

3.10.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the 116-F-8 outfall structure, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.10.3 Summary

Two sites, analogous to the 116-F-8 site and located in other source operable units, have been examined thus far by LFI. These are 116-D-5 and 116-DR-5. To assess the concept that these sites are analogous, a comparison of radionuclide and chemical analytical results from the LFI samples was performed. No inorganic compounds were detected in either of the analogous sites. No similarity exists for VOC, semi-volatile, or pesticide/PCB contamination in the analogous sites. Sites 116-DR-5 and 116-D-5 detected potassium-40 at 13.5 pCi/g and 12 pCi/g respectively. Table 3-15 presents a comparison of the maximum detected constituents in the analogous facilities.

3.10.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). The 116-F-8 outfall structure is located adjacent to the Columbia River and there are no downgradient wells to assess the impact to groundwater.

3.11 116-F-10 DUMMY DECONTAMINATION FRENCH DRAIN

The 116-F-10 dummy decontamination french drain was used from 1948 to 1965. This unit received radioactive water rinses and spent nitric acid from the decontamination of fuel element spacers and other reactor hardware, primarily pressure tube caps. The drain is made of 1 m (3 ft) diameter by 3 m (10 ft) vitrified tile with 1 m (3 ft) extending above grade. 116-F-10 is located about 61 m (100 ft) south of the 100 F Reactor Building. Today the surface in the area of the drain is covered with cobbles and there is little vegetation growing.

This unit received an estimated 400,000 l of liquid wastes. In addition to radionuclide contamination 116-F-10 also reportedly received 2,000 kg of sodium dichromate, 2,000 kg of sodium oxalate, and 2,000 kg of sodium sulfamate (Deford 1993).

Figure 3-3 shows the location of 116-F-10 dummy decontamination french drain.

3.11.1 Geology

The 100-FR-1 LFI did not include a field investigation of the 116-F-10 french drain. It is assumed that the drain is underlain by sediments similar to that found in the 116-F-6 vadose zone borehole.

3.11.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the 116-F-10 site, data are not available for the following:

- soil concentrations of organic, inorganic, and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.11.3 Summary

Dorian and Richards (1978) investigated three soil borings where samples were taken from 12.5 ft to 27 ft bls. The highest radionuclide concentrations were found in the 12.5 ft interval in soil boring "B". Radionuclides detected in the 12.5 ft sample were: tritium, cobalt-60, strontium-90, cesium-134, cesium-137, europium-152, europium-154, and europium-155. The highest of the detected radionuclides were: tritium, cobalt-60, europium-152, and europium-155. Appendix A presents the Dorian and Richards (1978) analytical results and sampling locations for the 116-F-10 site.

Two sites, 116-B-4 and 116-H-3, have been identified as being analogous to the 116-F-10 site. The LFI sampling data from the 116-H-3 site showed no VOC, semi-volatile, pesticide/PCB, inorganic, or radionuclide contamination. The sole source of sampling data for site 116-B-4 is from historical sampling. The estimated 1978 inventory of radionuclides for the 116-B-4 site were 2.0 Ci, the 116-H-3 site inventory was 0.07 Ci, and site 116-F-10 had an radionuclide inventory of 0.12 Ci (Dorian and Richards 1978).

3.11.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F8-2 is upgradient of site 116-F-10. Monitoring well 199-F5-47 is downgradient of site 116-F-10. Chromium values in the upgradient well were not appreciably different from those values found in the downgradient well. The maximum strontium-90 concentration in upgradient well 199-F8-2 was 41 pCi/l, and the maximum concentration in the downgradient well 199-F5-47 was 3.8 pCi/l. It does not appear that the 116-F-10 trench is currently impacting groundwater.

3.12 116-F-11 CUSHION CORRIDOR FRENCH DRAIN

The 116-F-11 cushion corridor french drain is an inactive liquid waste site used between 1953 and 1965. The drain is located near the southeast corner of the 105-F reactor building and was used to dispose of cushion corridor liquid decontamination wastes. This unit is a tile pipe 1 m (3 ft) in diameter and a depth of 1 m (3 ft), extending about an inch or two above grade. It has a metal lid and is protected with three yellow steel stand pipes. There are no radioactive material warning signs or other identifying markers (Deford 1993).

This disposal unit received 200,000 l of liquid decontamination wastes from the cushion corridor area of the reactor. No documentation could be located that characterizes the waste transferred to the 116-F-11 drain or that estimates the radionuclide content. Figure 3-3 shows the location of the 116-F-11 french drain (DOE-RL 1992a).

3.12.1 Geology

The 100-FR-1 LFI did not include a field investigation of the 116-F-11 french drain. It is assumed that the drain is underlain by sediments similar to that found in the 116-F-3 vadose zone borehole.

3.12.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the 116-F-11 site, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils

- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.12.3 Summary

No documentation could be located that characterizes the waste transferred to the 116-F-11 drain or that estimates radionuclide content. Site 116-D-6 is an analogous site that was investigated for the 100-DR-1 LFI. Volatile organics and semi-volatile organics were detected at levels below the CRQL in the 116-D-6 borehole. No pesticides or PCB were detected, and no inorganics were detected above the Hanford Site 95% UTL. Radionuclides detected were: carbon-14, potassium-40, radium-226, thorium-228, uranium-235, uranium-238, plutonium-239, americium-241. Potassium-40 was the only constituent detected above 1 pCi/g. Site 116-D-6 operated for 6 years while 116-F-11 was in operation for 12 years so the radionuclide inventory for site 116-F-11 could potentially be greater.

3.12.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-4 is downgradient of site 116-F-11. No monitoring well is located close enough to this site to be considered an upgradient well. In well 199-F5-4 the maximum detection of chromium was 21.1 μg/l in December of 1993. No strontium-90 was detected in well 199-F5-4. Since no upgradient values were available, the impact to groundwater from the 116-F-11 site could not be determined.

3.13 116-F-12 FRENCH DRAIN

The 116-F-12 french drain was used from 1944 to 1964 and is located about 2 m (8 ft) east of the original site of the 148-F pump house and lift station. The drain was used from 1944 to 1964 to receive effluent pump prime from the lift station. The drain measured 1 m (3 ft) in diameter and was placed 2 m (6 ft) deep. The construction material is unknown, but probably consisted of clay or concrete pipe that was typical of other drains used in this era.

No information could be located that characterizes the waste effluent or provides radionuclide or hazardous chemical inventories. Figure 3-3 shows the location of the 116-F-12 french drain.

3.13.1 Geology

The 100-FR-1 LFI did not include a field investigation of the 116-F-12 french drain. It is assumed that the drain is underlain by sands and gravels similar to those found in other waste sites.

3.13.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the 116-F-12 site, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.13.3 Summary

No documentation could be located that characterizes the waste transferred to the 116-F-11 drain or that estimates its radionuclide content. No analogous facilities were sampled.

3.13.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-46 is upgradient of site 116-F-12. Monitoring well 199-F5-44 is downgradient of site 116-F-12. Chromium and strontium-90 concentrations are higher in well 199-F5-46 than in the downgradient well 199-F5-44 suggesting that the 116-F-12 french drain is not currently impacting groundwater.

3.14 116-F-13 EXPERIMENTAL GARDEN FRENCH DRAIN

The 116-F-13 experimental garden french drain was used from 1952 to 1976 to dispose of effluent from radio-botany experiments conducted in the 1705-F facilities. This unit is 1 m (3 ft) in diameter and 1 m (3 ft) deep and is located in the northwest corner of the animal research and testing area.

The drain received 10,000 l of liquid wastes, however, no data could be located that characterizes the waste effluent or provides radionuclide or hazardous chemical inventories. Figure 3-3 shows the location of the 116-F-13 french drain.

3.14.1 Geology

The 100-FR-1 LFI did not include a field investigation of the 116-F-13 french drain. It is assumed that the drain is underlain by sands and gravels similar to that found in other waste sites.

3.14.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the 116-F-13 site, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.14.3 Summary

No documentation could be located that characterizes the waste transferred to the 116-F-13 drain or that estimates its radionuclide content. No analogous facilities were found to exist for the 116-F-13 experimental garden french drain.

3.14.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-46 is upgradient of site 116-F-13. Monitoring well 199-F5-44 is downgradient of site 116-F-13. Chromium and strontium-90 concentrations are higher in well 199-F5-46 than in the downgradient well 199-F5-44 suggesting that the 116-F-13 experimental garden french drain is not currently impacting groundwater.

3.15 PROCESS/DISCHARGE PIPELINES

During the reactor operating period, three separate pipelines were used to transfer water from the F Reactor building to the 116-F-14 retention basin. The oldest pipeline was a 107-cm (42-in) diameter concrete belowground pipe. This pipe was replaced with a 107-cm (42-in) diameter steel pipe with aboveground and belowground sections in the early years of operation. Deterioration and increased flow requirements resulted in the installation of a third, 152-cm (60-in) diameter steel pipe, which also had aboveground and belowground sections. Portions of the steel pipes have been removed and buried in the 116-F-14 retention basin (DOE-RL 1992a).

3.15.1 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the process/discharge pipelines, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils

- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.15.2 Summary

Four sample borings were completed (Dorian and Richards 1978) along the aboveground sections of the 107-cm (42-in) and 152-cm (60-in) pipes at points located several hundred feet upstream from the retention basin inlet. No significantly elevated concentrations of radionuclides were observed. Samples of scale inside the 107-cm (42-in) effluent line were collected. The radionuclide concentrations in the scale were 170 pCi/g for cobalt-60, 250 pCi/g for cesium-137, and 490 pCi/g for europium-155. Two constituents, europium-152 and europium-154, were not reported above method detection limits. Appendix A presents the Dorian and Richards (1978) sampling results and soil boring locations.

Analyses for inorganic, metal, and organic constituents was not performed by Dorian and Richards (1978), but the LFI data for the 116-F-14 retention basin sludge could be considered analogous to the sludge and scale from the pipelines.

3.15.3 Groundwater Assessment

Because of the extensive nature of the process/discharge pipelines and their proximity to other waste sites a groundwater assessment based upon the current monitoring wells is not possible.

3.16 UN-100-F-1

The only documented unplanned release in the 100-FR-1 Operable Unit occurred in March 1971, when the process sewer line from the 141-C hog barn became blocked and overflowed into the surface adjacent to the building. The area of the spill is approximately 149 m^2 (1600 ft^2) and is located east of the 141-C building. This site received wash water from the animal pens when liquids were pumped from a manhole to unblock the sewer. The wash water contained 4.00E-05 Ci of strontium-90 and 1.06E-06 Ci of plutonium-239. About 1,600 ft^2 of soil was contaminated (Stenner et al. 1988).

The area was backfilled with clean gravel after the incident. The area appears today as a level, grass-covered field. Figure 3-3 shows the location of the spill.

3.16.1 Geology

The 100-FR-1 LFI did not include a field investigation of the UN-100-F-1 french drain. It is assumed that the spill is underlain by sands and gravels similar to that found in other waste sites.

3.16.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the UN-100-F-1 site, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.16.3 Summary

Dorian and Richards (1978) did not sample UN-100-F-1. No analogous facilities exist for the UN-100-F-1 unplanned release.

3.16.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-46 is upgradient of site UN-100-F-1. Monitoring well 199-F5-44 is downgradient of site UN-100-F-1. Chromium and strontium-90 concentrations are higher in well 199-F5-46 than in the downgradient well 199-F5-44 suggesting that the UN-100-F-1 site is not currently impacting groundwater.

3.17 132-F-6 LIFT STATION DEMOLITION SITE

The 132-F-6 lift station is located at the southeast corner of the 105-F reactor building. It operated from 1944 until 1965 to pump waste water from several reactor building drains and sumps into the reactor cooling water effluent line. It may have also pumped wastes to the 116-F-6 trench.

Constituents likely to be associated with waste at this site include radionuclides (e.g., tritium, carbon-14, cobalt-60, strontium-90, cesium-137, europium-152, and europium-154) and decontamination chemicals (e.g., sodium fluoride, nitric acid, and oxalic acid). The lift station was demolished in situ in 1987 and backfilled with a minimum of 5 m (15 ft) of clean fill. Fixtures, equipment, asbestos lagging, and sludge were removed and buried elsewhere as solid waste (Deford 1993). The site appears today as a level, gravel covered field (Deford 1993). Figure 3-3 shows the location of 132-F-6.

3.17.1 Geology

The 100-FR-1 LFI did not include a field investigation of the 132-F-6 Lift Station. It is assumed that the lift station demolition site is underlain by sands and gravels similar to those found in other waste sites.

3.17.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the 132-F-6 site, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.17.3 Summary

Dorian and Richards (1978) sampled from a single location adjacent to the lift station prior to demolition. Samples were collected at 5 ft, 25 ft, and 30 ft bls. The maximum contamination was found in the 5 ft interval, with europium-152 (92 pCi/g) being the highest value detected. A complete listing of the Dorian and Richards (1978) analytical results and soil boring locations are presented in Appendix A. Since the historical data were collected before 132-F-6 was demolished, they probably do not represent the present status of the site.

Data collected from the analogous site 132-D-3 showed no organic or inorganic contaminants and the only radionuclide contamination found was radium-226 at <1 pCi/g.

3.17.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring wells 199-F5-47 and 199-F5-4 are downgradient of site 132-F-6. No monitoring well is located close enough to this site to be considered an upgradient well. In well 199-F5-47 the maximum detection of chromium was 20.7 μg/l in April of 1993. The maximum level of strontium-90 was detected in April 1993 at 3.8 pCi/l. In well 199-F5-4 the maximum detection of chromium was 19.7 μg/l in April of 1993. Strontium-90 was not detected in well 199-F5-4. Since no upgradient values were available, the impact to groundwater from the 132-F-6 site could not be determined.

3.18 PNL OUTFALL STRUCTURE

The PNL outfall structure is located a few meters upstream of the 116-F-8 outfall structure. It was a simple spillway and measured 30 m (100 ft) by 3 m (10 ft) wide with concrete side walls. This outfall structure received liquid waste from the animal pens that was contaminated with strontium-90 and smaller amounts of cesium-137 and plutonium-239. It also likely received cooling water effluent used in the 146-F Aquatic Biology Laboratory.

Only the lower portion of the PNL outfall structure is intact and visible today. The vertical walls of the upper section were broken down and the walls and bottom of the spillway were covered with soil (Deford 1993).

No radionuclide or hazardous chemical inventory was located for this site. Figure 3-3 shows the location of the PNL Outfall Structure.

3.18.1 Geology

No site specific geologic data are available for the PNL Outfall Structure.

3.18.2 LFI Data

Because the 100-FR-1 LFI did not include a field investigation of the PNL outfall structure, data are not available for the following:

- soil concentrations of organic, inorganic and metallic constituents
- physical properties of the soils
- field screening for VOC and radiological contamination
- geophysical borehole logs.

3.18.3 Summary

No radionuclide or hazardous chemical inventory is available for this site, nor has any soil sampling been accomplished in the immediate area. No analogous facilities were found to exist for the PNL outfall structure.

3.18.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). The PNL outfall structure is located adjacent to the Columbia River and there are no downgradient wells to assess the impact to groundwater. The probability of impact to groundwater posed by outfall structures was rated low in the 100-FR-1 QRA (WHC 1993).

3.19 132-F-1 CHRONIC FEEDING BARN

The 132-F-1 chronic feeding barn served as the main housing facility for sheep and other livestock used in dose studies. The primary radionuclides used in these studies were strontium-90, iodine-131, cesium-137, and plutonium-239. The chronic feeding barn was cleaned and washed down regularly, with the waste water going to the 1607-F6 sewer system. No records of decommissioning activities were found but it is assumed that it was demolished sometime after 1980 and buried in place.

No historical records of radionuclide or hazardous chemical inventory exist for this facility. Figure 3-2 shows the location of the 132-F-1 chronic feeding barn.

3.19.1 Geology

Limited field investigation of the 132-F-1 Chronic Feeding Barn consisted of one test pit which was excavated to a depth of 6 ft bls. There is no geologic description from this activity but it is assumed that the lithology is composed of sands and gravels that were encountered at other waste sites.

3.19.2 132-F-1 Test Pit Soil Samples

One sample and three quality assurance samples were taken at a depth of 4 ft bls, sample B02701, B02702 (duplicate), B02703 (split), and B02704 (silica sand-blank).

3.19.2.1 Chemical Analysis. Acetone was detected in excess of the CRQL (10 μg/kg) in the split sample (B07203) at 54 μg/kg. Acetone was not detected in any of the other samples. Table 3-16 presents a summary of the volatile organics detected.

No semi-volatile organic compounds were detected above the CRQL (330 μg/kg), with the exception of bis(2-ethylhexyl)phthalate (380 μg/kg) in the split sample (B07203). Table 3-16 summarizes the detected semi-volatile organic compounds.

Gamma-chlordane was detected in sample B07201 (2.5 μg/kg) and its duplicate sample B07202 (4.7 μg/kg). No other pesticides or PCB were detected.

No inorganics constituents or metals were detected above the Hanford Site background 95% UTL.

3.19.2.2 Radionuclide Analysis. Table 3-16 presents a summary of the detected radionuclide concentration in the 132-F-1 test pit. The maximum gross alpha detection was 4.2 pCi/g in the split sample B07203. The maximum gross beta detection was 35 pCi/g also in the split sample B07203. The maximum radionuclide detection was 13 pCi/g of potassium-40, all other radionuclide concentrations were < 1 pCi/g.

3.19.2.3 Field Screening. Volatile organic compounds were field screened using an OVM PID. No VOC were detected during the 132-F-1 chronic feeding Barn investigation. No radionuclides were detected during field screening above the background level of 150 cpm.

3.19.3 Summary

Acetone was detected in one QC sample but in no other samples greater than the CRQL. No semi-volatiles were detected above the CRQL. Gamma-chlordane was detected in sample B07201 and its duplicate sample, no other pesticides or PCB were detected. Only potassium-40 was detected in excess of 1 pCi/g, with a maximum of 13 pCi/g. No historical sampling data or analogous site data were available for comparison.

3.19.4 Groundwater Assessment

Figures 3-4 and 3-5 present maximum concentrations of chromium and strontium-90 in 100-FR-3 groundwater from December 1992 through July 1993 sampling rounds (DOE-RL 1994b). Monitoring well 199-F5-46 is upgradient of site 132-F-1. Monitoring well 199-F5-44 is downgradient of site 132-F-1. Chromium and strontium-90 concentrations are higher in well 199-F5-46 than in the downgradient well 199-F5-44 suggesting that the 132-F-1 chronic feed barn is not currently impacting groundwater.

3.20 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986, requires that fund-financed, enforcement, and federal facility remedial actions comply with ARAR of federal environmental laws and more stringent, promulgated state environmental or facility siting laws.

Comprehensive Environmental Response, Compensation and Liability Act defines applicable requirements as those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

In addition to ARAR, CERCLA also provides for the consideration of to-be-considered (TBC) guidance, nonpromulgated advisories or guidance documents issued by federal or state governments that do not have the status of potential ARAR but which may be considered in determining necessary levels of protection of health or the environment.

Applicable or relevant and appropriate requirements may be further subdivided into the following categories:

- *Chemical-specific requirements* - health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values. If a chemical has more than one such requirement that is ARAR, compliance should generally be with the most stringent requirement.

- *Location-specific requirements* - restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations, such as wetlands or historic places.

- *Action-specific requirements* - technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy.

Potential chemical- and location-specific ARAR are defined during the field investigation portion of the CERCLA process and refined in the feasibility study and proposed plan. Action-specific ARAR are generally defined during the phase I and II feasibility study and refined in detailed analysis and the proposed plan. Potential ARAR and TBC in all categories are defined in the *100 Area Feasibility Study, Phases 1 and 2* (DOE-RL 1992c). For purposes of this LFI, only the potential chemical- and location-specific ARAR are discussed. Potential chemical- and location-specific ARAR are used in the LFI report as screening criteria for the evaluation of high-priority sites as IRM candidates. This use of ARAR is not intended to set cleanup standards for the high-priority sites. Potential chemical- and location-specific ARAR are presented in Tables 3-17 through 3-22.

Potential chemical-specific ARAR for soils are limited to those levels for hazardous constituents prescribed in the state's Model Toxics Control Act (MTCA). Currently, MTCA has not defined levels for radionuclides. Additional soil limits are presented in Subpart S of RCRA for hazardous constituents and in DOE Order 5400.5 for radionuclides. These are considered TBC for the 100 Area operable units. Potential chemical-specific ARAR for air emissions are also identified for the 100 Area; however, these tend to also be based on specific actions which have a tendency to increase releases to the air. Therefore, these are more appropriately addressed in the focused feasibility study. Potential chemical-specific ARAR are listed in Table 3-17 and 3-18; TBC are included in Table 3-19.

Potential location-specific ARAR are identified for the 100 Area because of the presence of threatened or endangered species and archaeological resources. In addition, potential location-specific ARAR based on possible impacts to wetlands and floodplains are included. These are described in Tables 3-20 and 3-21; TBC are in Table 3-22.

This discussion of potential ARAR is intended to be a refinement of ARAR presented in the work plan. Additional evaluation of potential ARAR will be done in the FS phase. Final ARAR will be determined in the record of decision.

Figure 3-1 Limited Field Investigation Intrusive Sampling Locations (Reactor Vicinity)

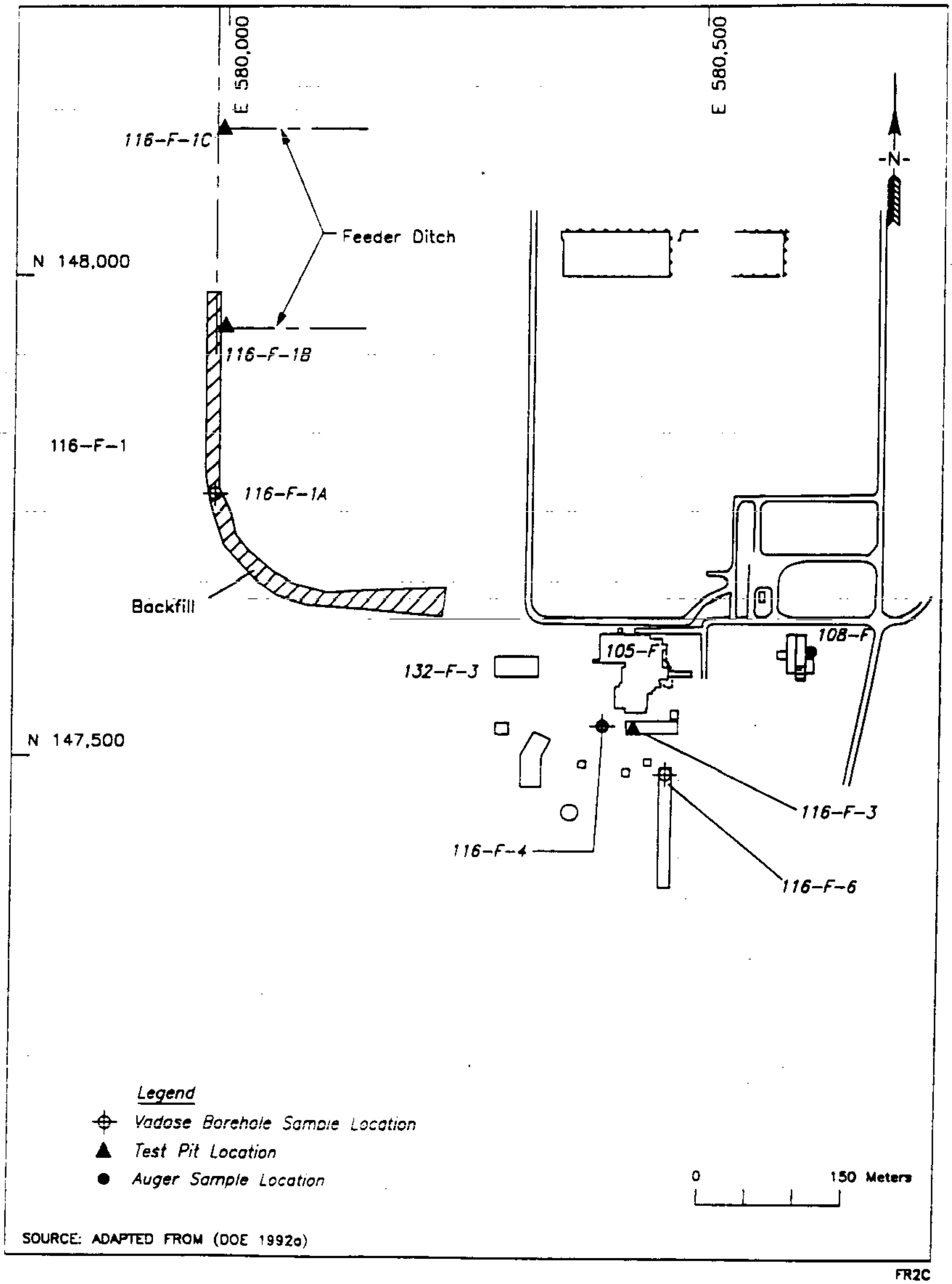


Figure 3-2 Limited Field Investigation Intrusive Sampling Locations (Retention Basin Vicinity)

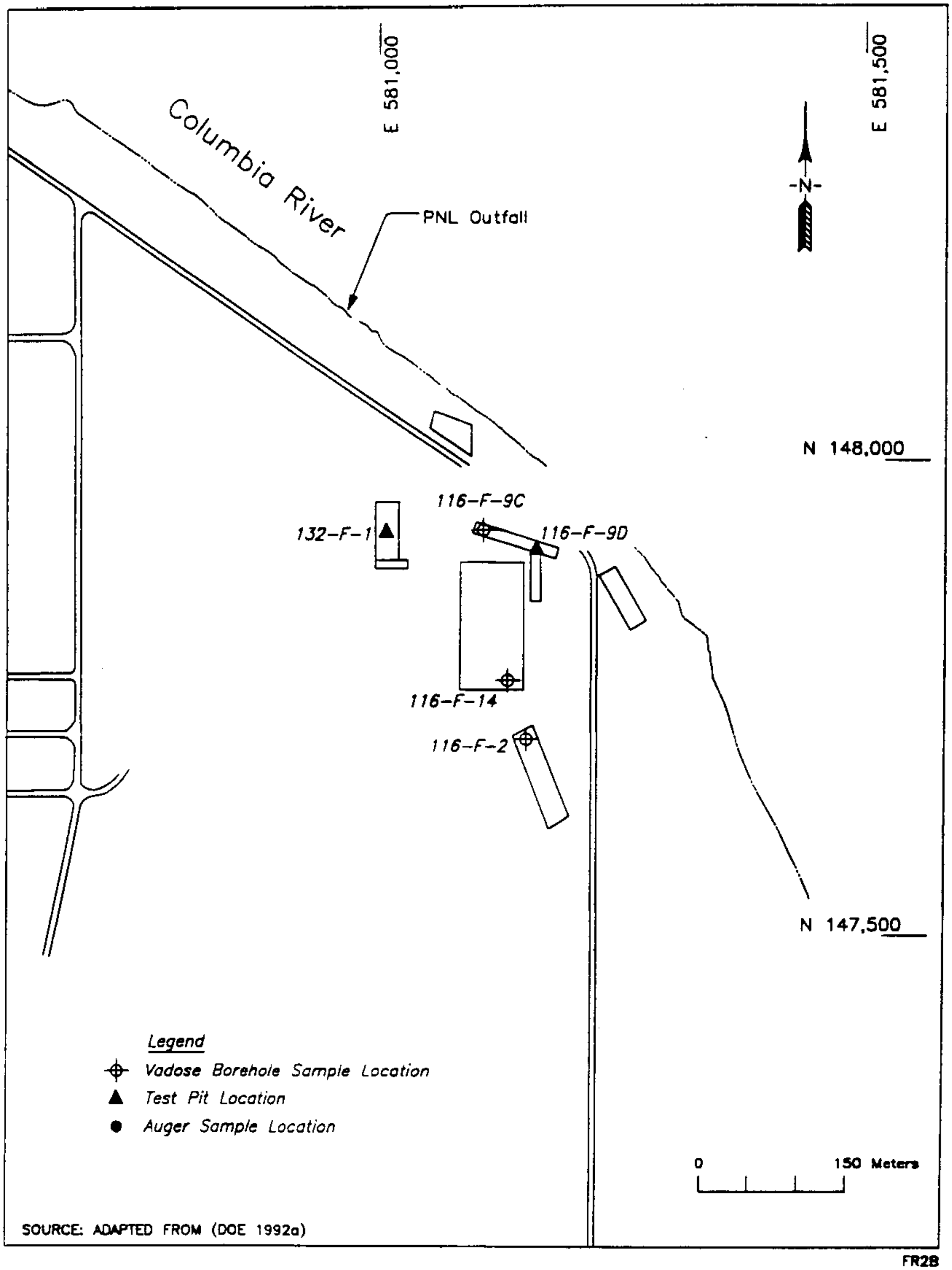


Figure 3-3 Limited Field Investigation Facility Locations

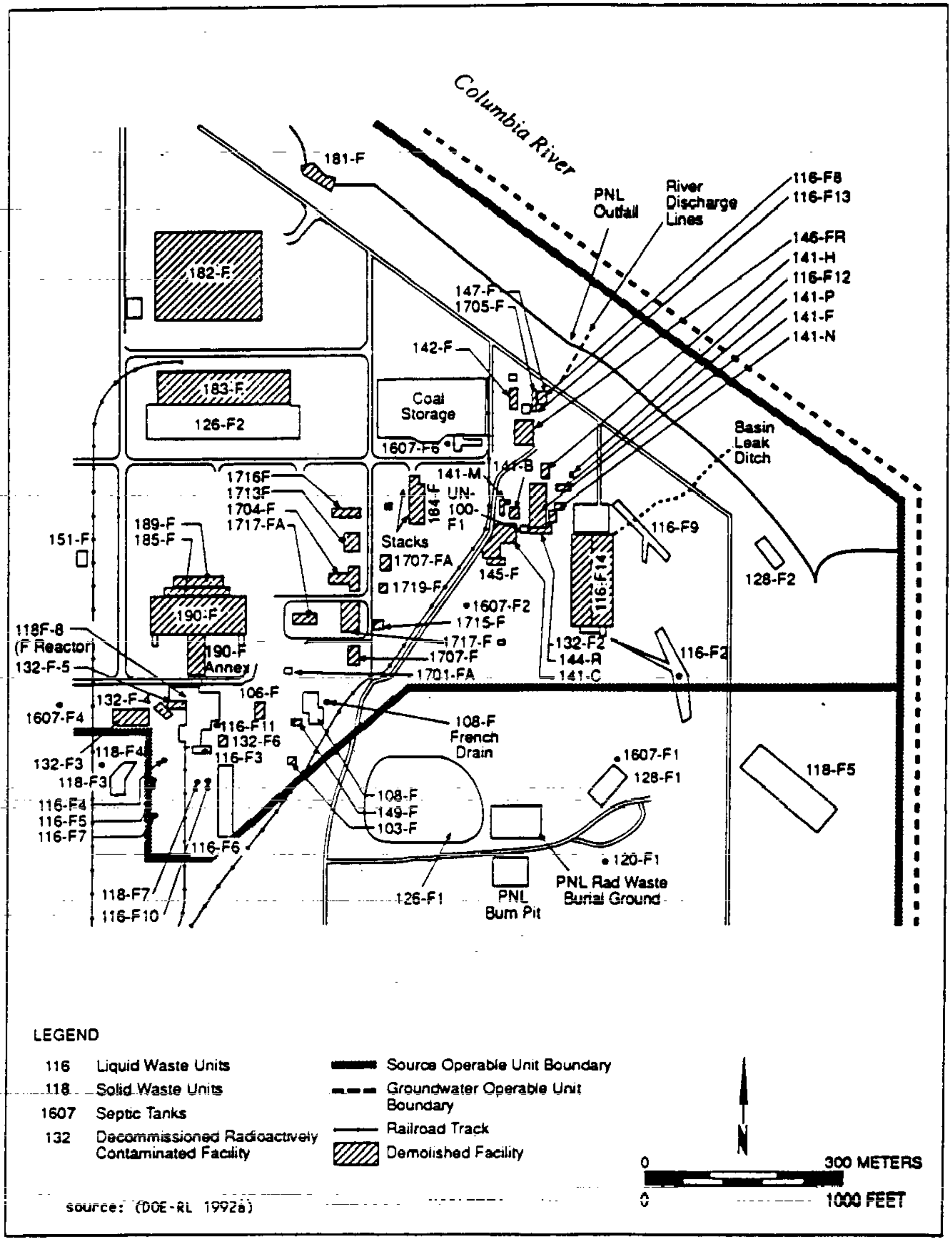
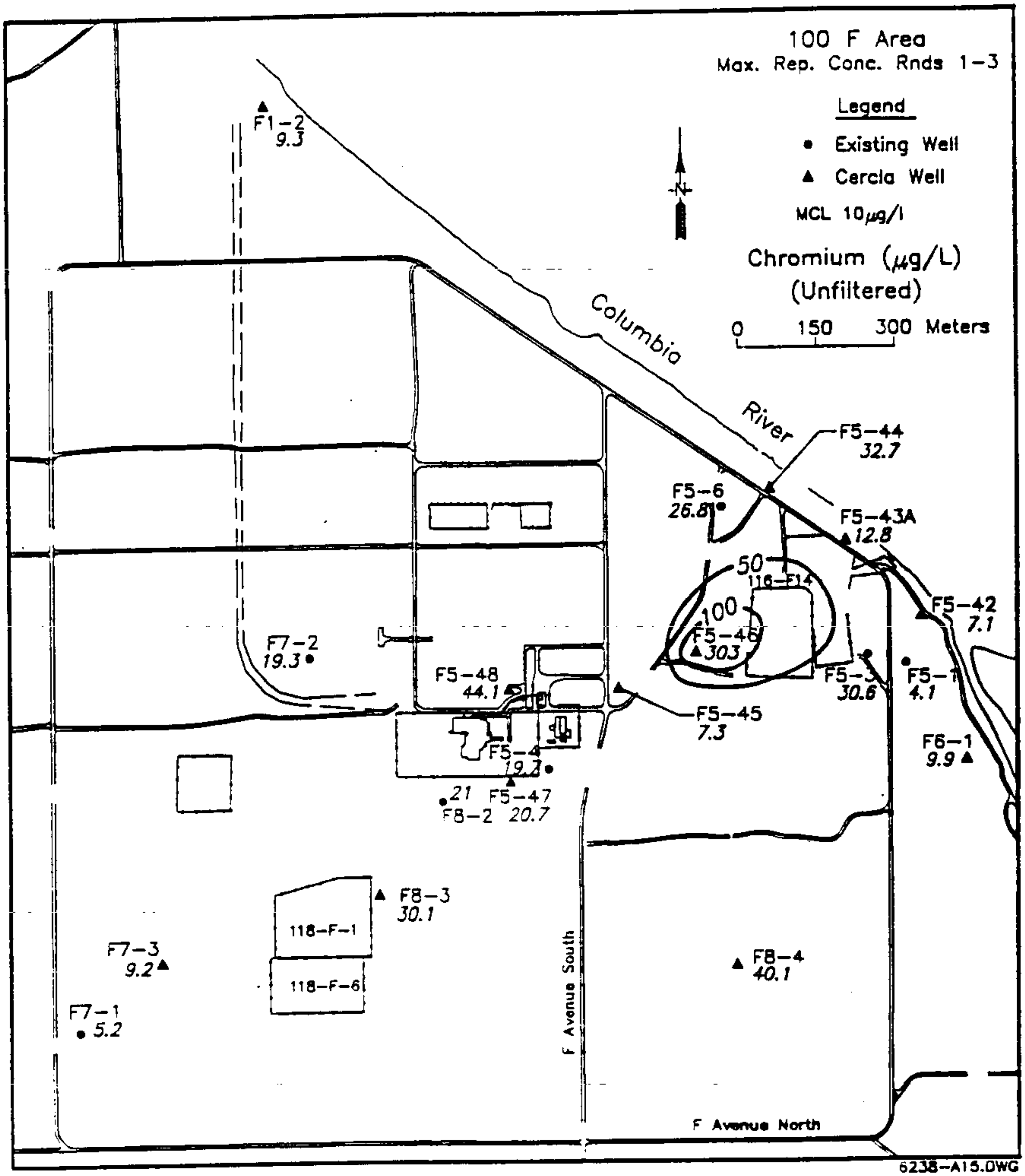


Figure 3-4 Total Chromium Concentrations in Groundwater, Maximum 1992/93 Values From 100-FR-3 Monitoring Wells



DOE-RL 1994b

Figure 3-5 Strontium-90 Concentrations in Groundwater, Maximum 1992/93 Values From 100-FR-3 Monitoring Wells

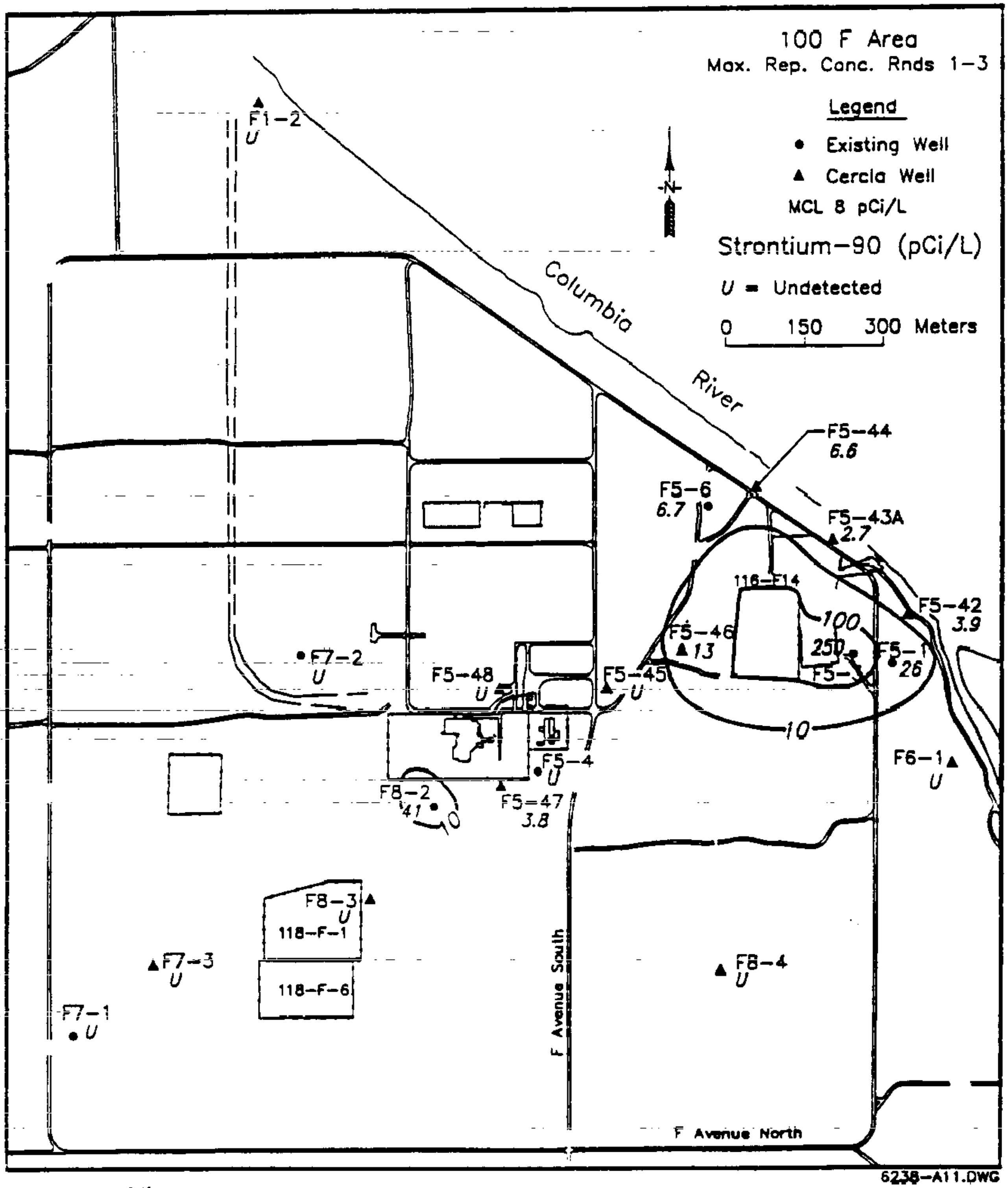


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Figure 3-6 Summary Diagram of 116-F-1A LFI Borehole Data

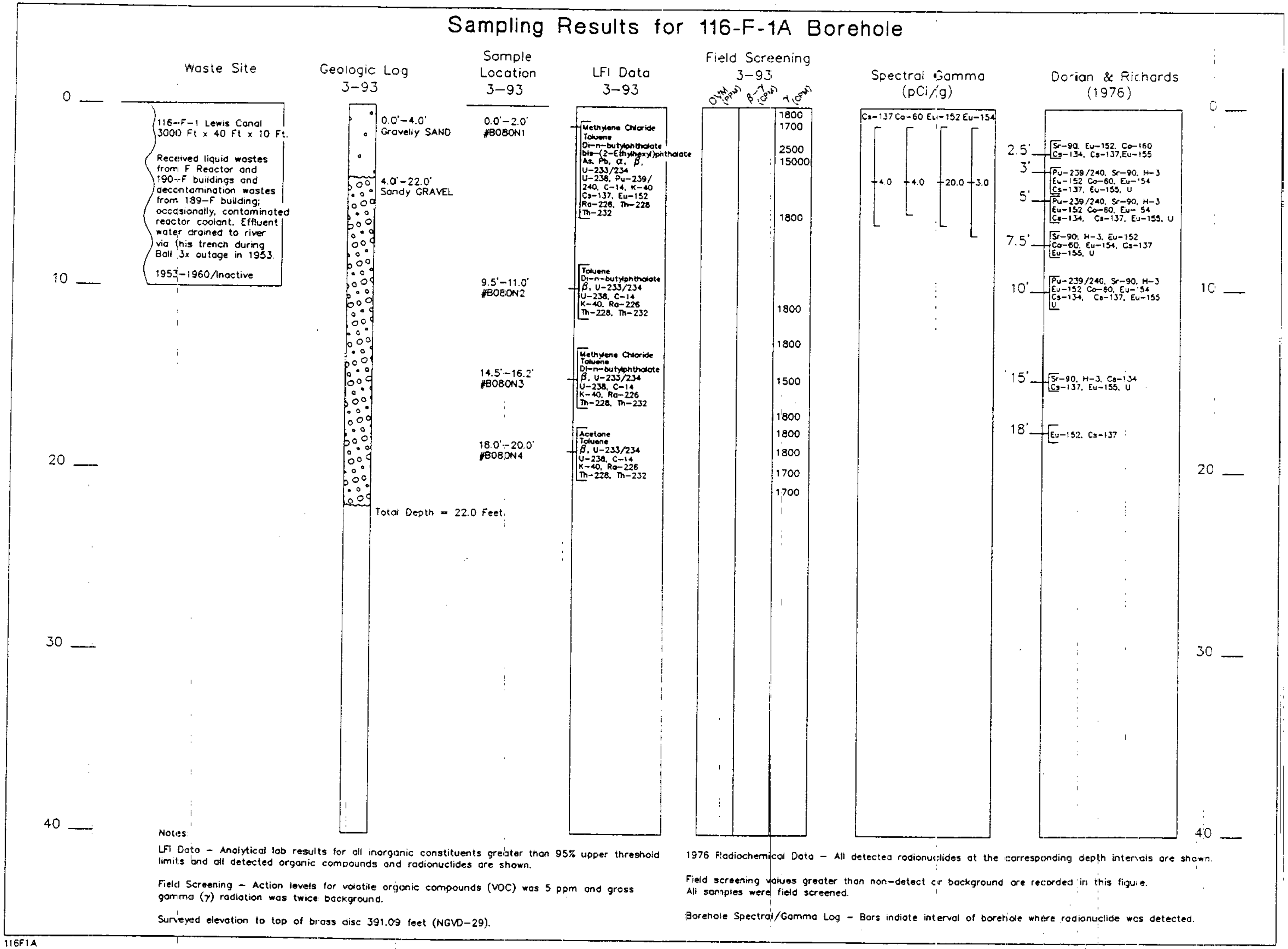

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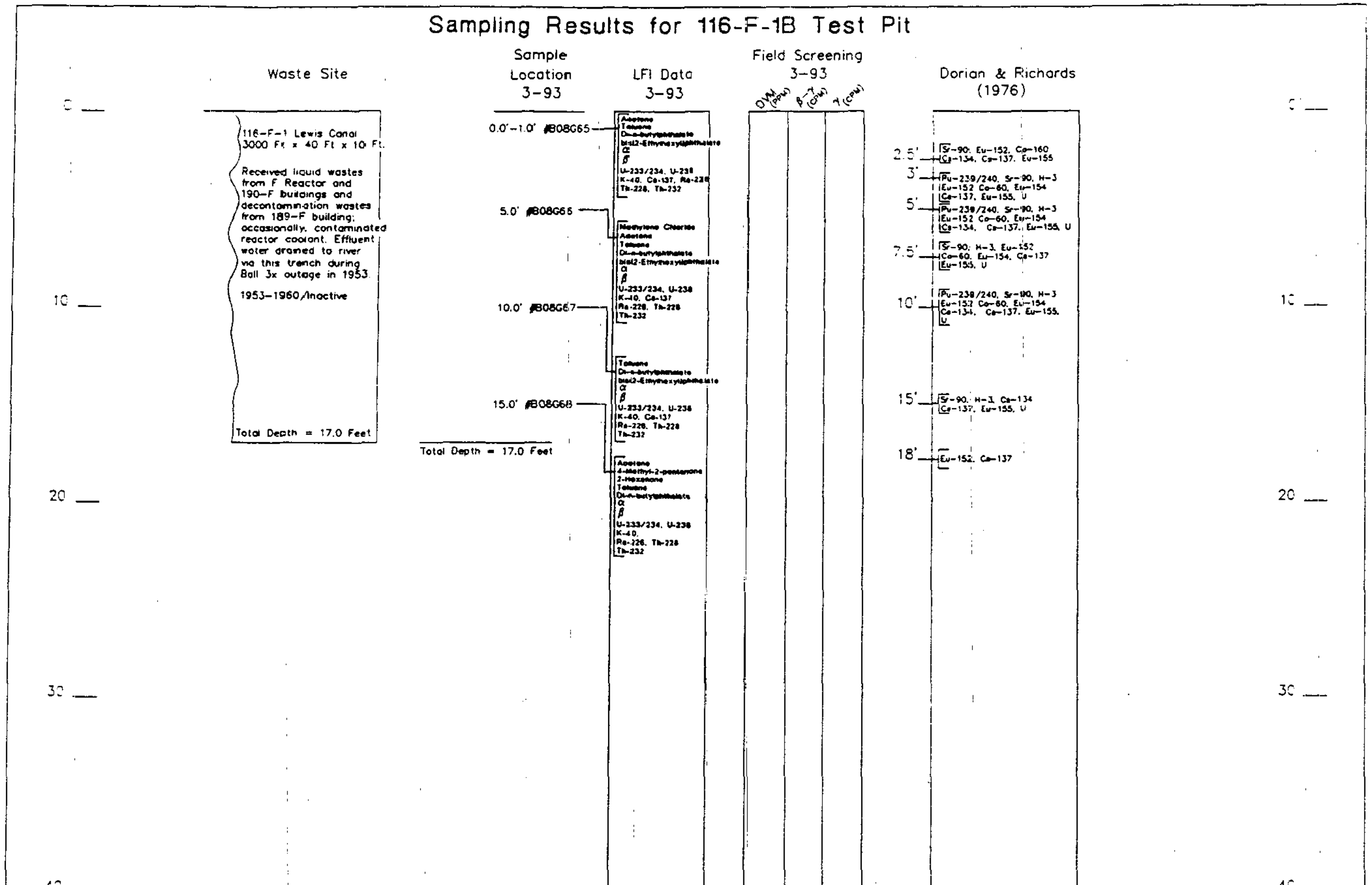
Figure 3-7 Summary Diagram of the 116-F-1B LFI Test Pit Data



Notes:

LFI Data – Analytical lab results for all inorganic constituents greater than 95% upper threshold limits and all detected organic compounds and radionuclides are shown.

Field Screening – Action levels for volatile organic compounds (VOC) was 5 ppm and gross gamma (γ) radiation was twice background.

1976 Radiochemical Data – All detected radionuclides at the corresponding depth intervals was shown.

Field screening values greater than non-detect or background are recorded in this figure. All samples were field screened.

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Figure 3-8 Summary Diagram of the 116-F-1C LFI Test Pit

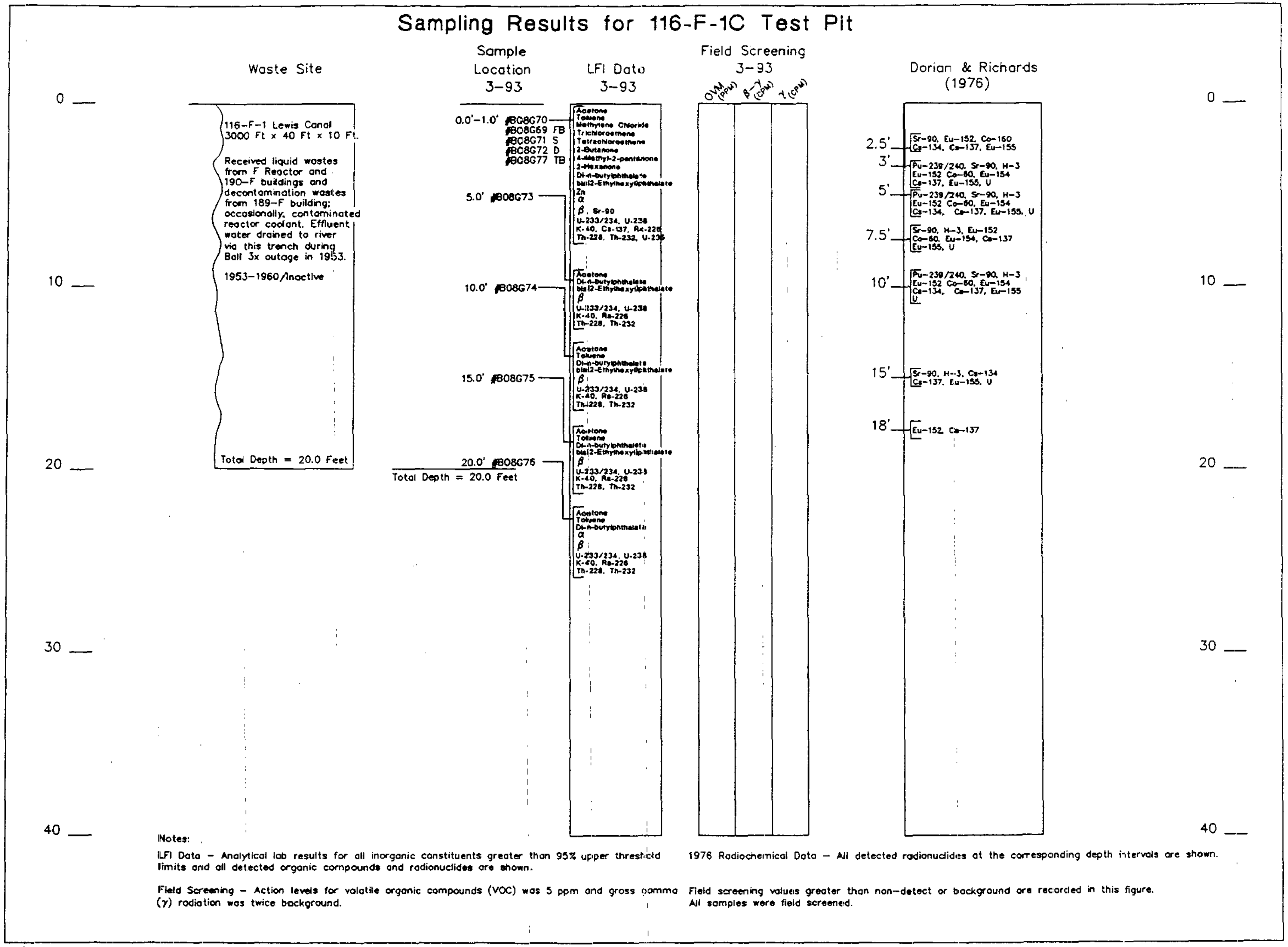

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Figure 3-9 Summary Diagram of the 116-F-2 LFI Borehole Data

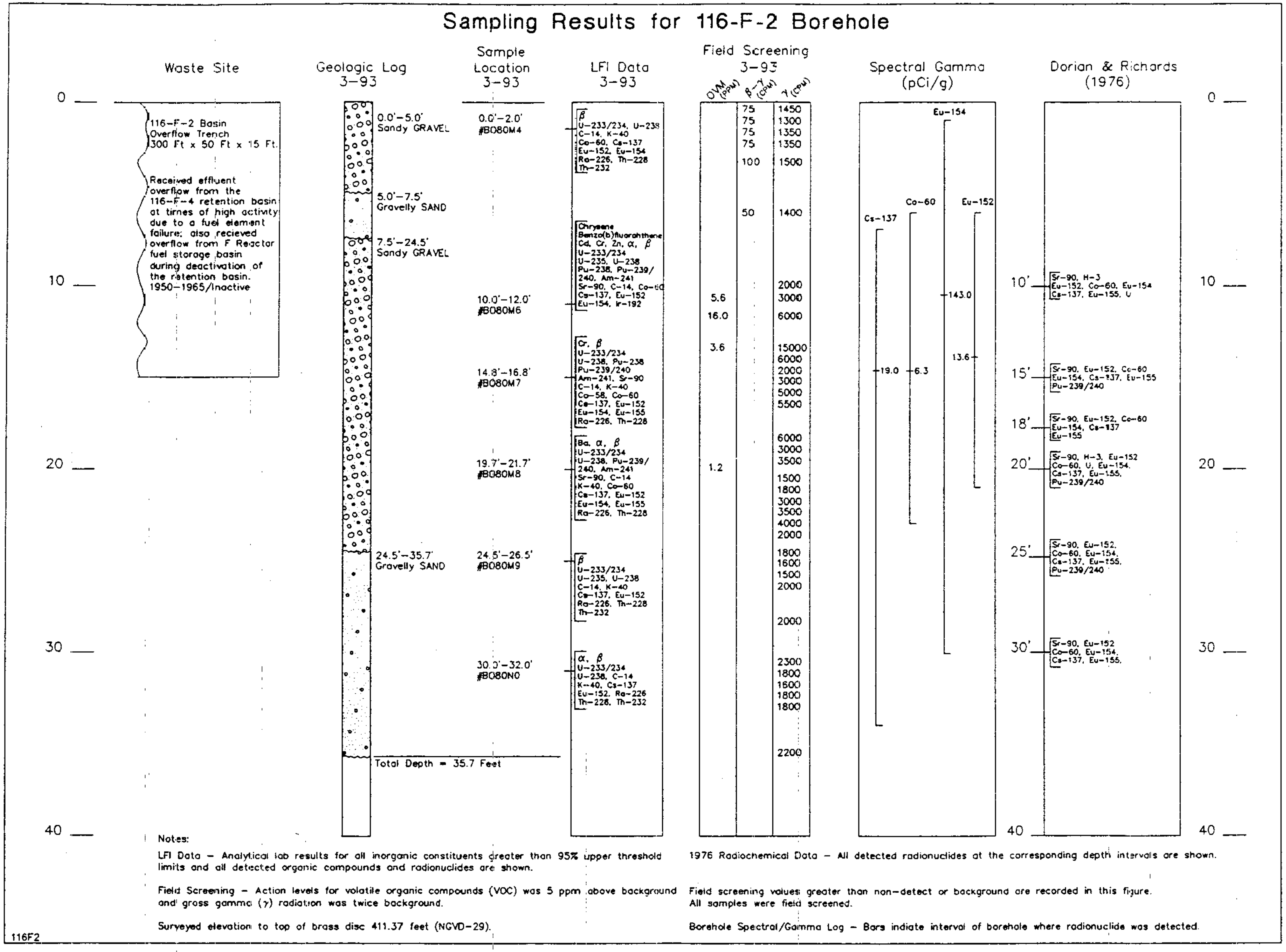

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**Figure 3-10 Summary Diagr
of the 116-F-3 LFI Test Pit Data**

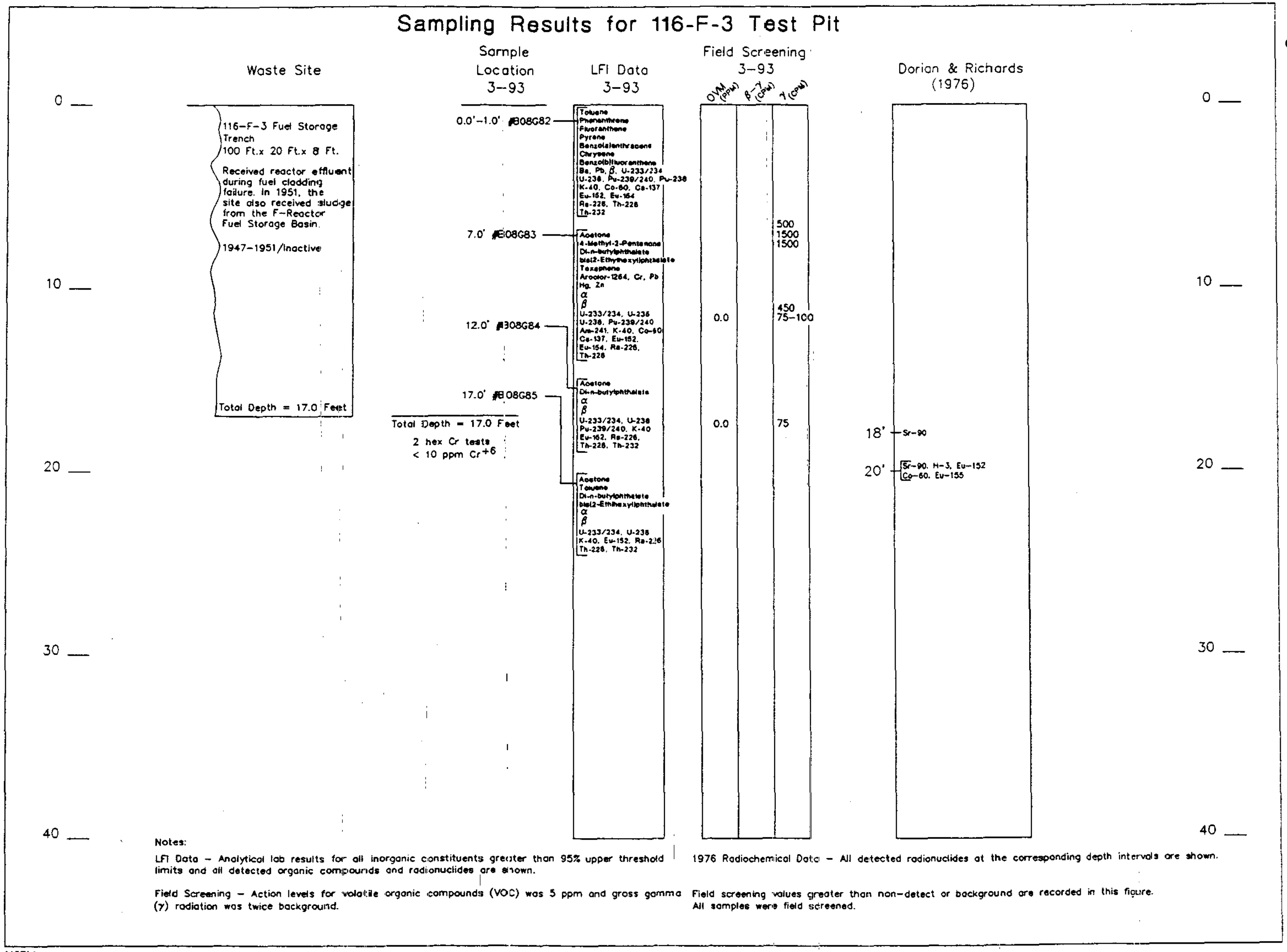

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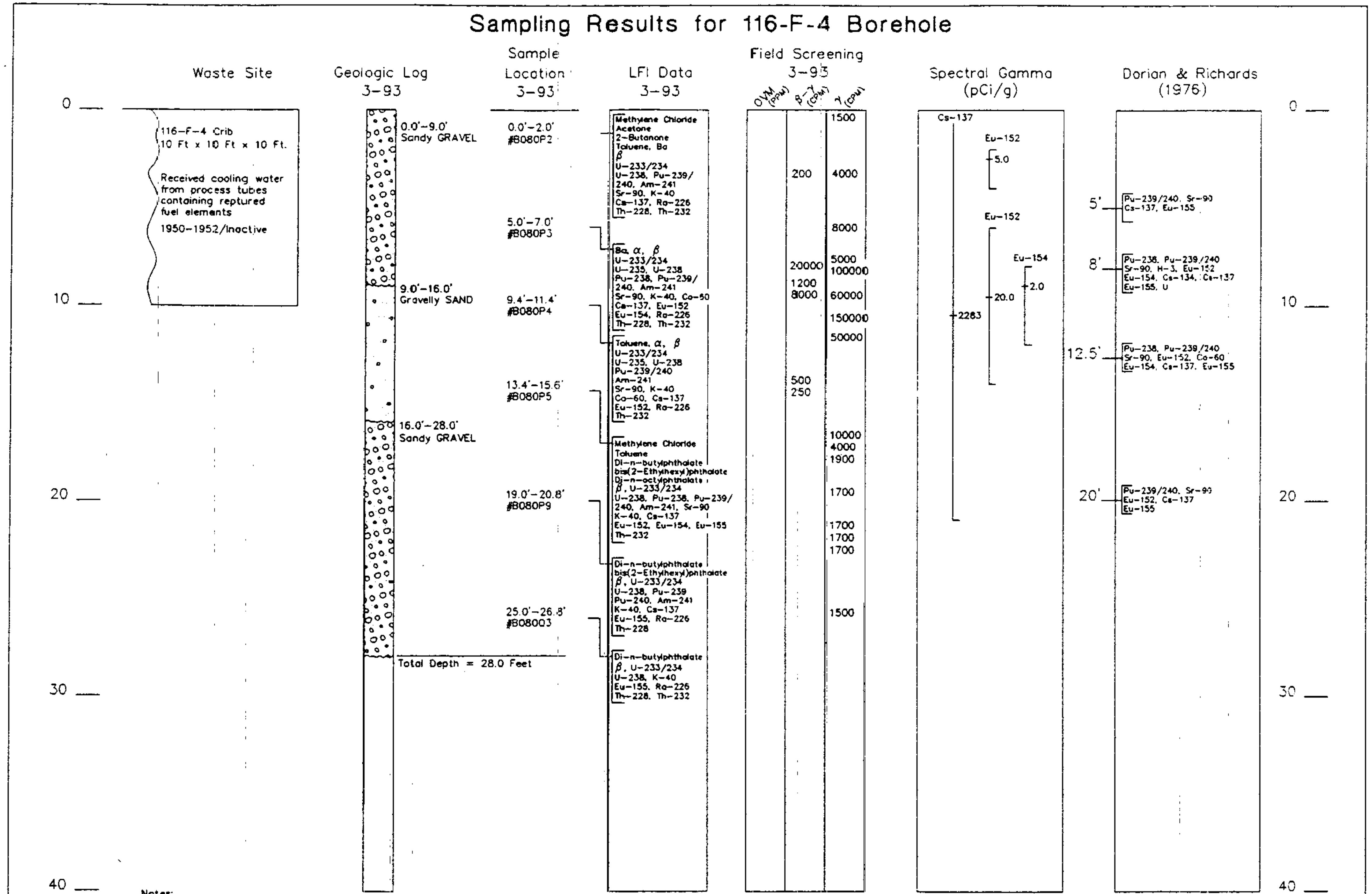
Figure 3-11 Summary Diagra[m] of the 116-F-4 LFI Borehole Da[ta]



Notes:

LFI Data – Analytical lab results for all inorganic constituents greater than 95% upper threshold limits and all detected organic compounds and radionuclides are shown.

Field Screening – Action levels for volatile organic compounds (VOC) was 5 ppm above background and gross gamma (γ) radiation was twice background.

Surveyed elevation to top of brass disc 411.81 feet (NGVD-29).

1976 Radiochemical Data – All detected radionuclides at the corresponding depth intervals are shown.

Field screening values greater than non-detect or background are recorded in this figure.
All samples were field screened.

Borehole Spectral/Gamma Log – Bars indicate interval of borehole where radionuclide was detected.

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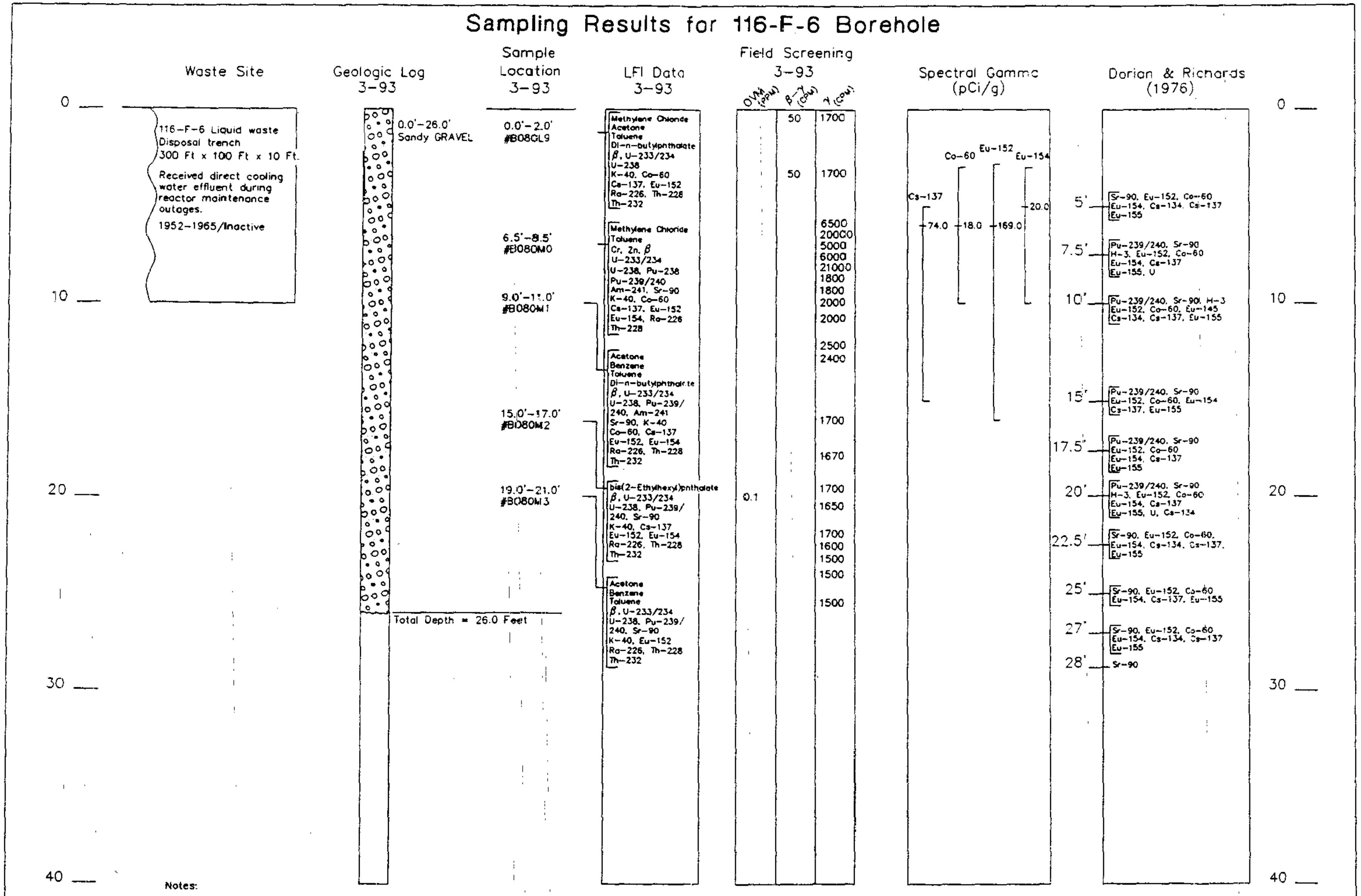
Figure 3-12 Summary Diag[ram] of the 116-F-6 LFI Borehole I[...]



Notes:

LFI Data – Analytical lab results for all inorganic constituents greater than 95% upper threshold limits and all detected organic compounds and radionuclides are shown.

Field Screening – Action levels for volatile organic compounds (VOC) was 5 ppm above background and for gross gamma (γ) radiation was twice background.

Surveyed elevation to top of brass disc 413.09 feet (NGVD-29).

1976 Radiochemical Data – All detected radionuclides at the corresponding depth intervals are shown.

Field screening values greater than non-detect or background are recorded in this figure. All samples were field screened.

Borehole Spectral/Gamma Log – Bars indiate interval of borehole where radionuclide was detected.

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Figure 3-13 Summary Diagr
of the 116-F-9C LFI Borehole D

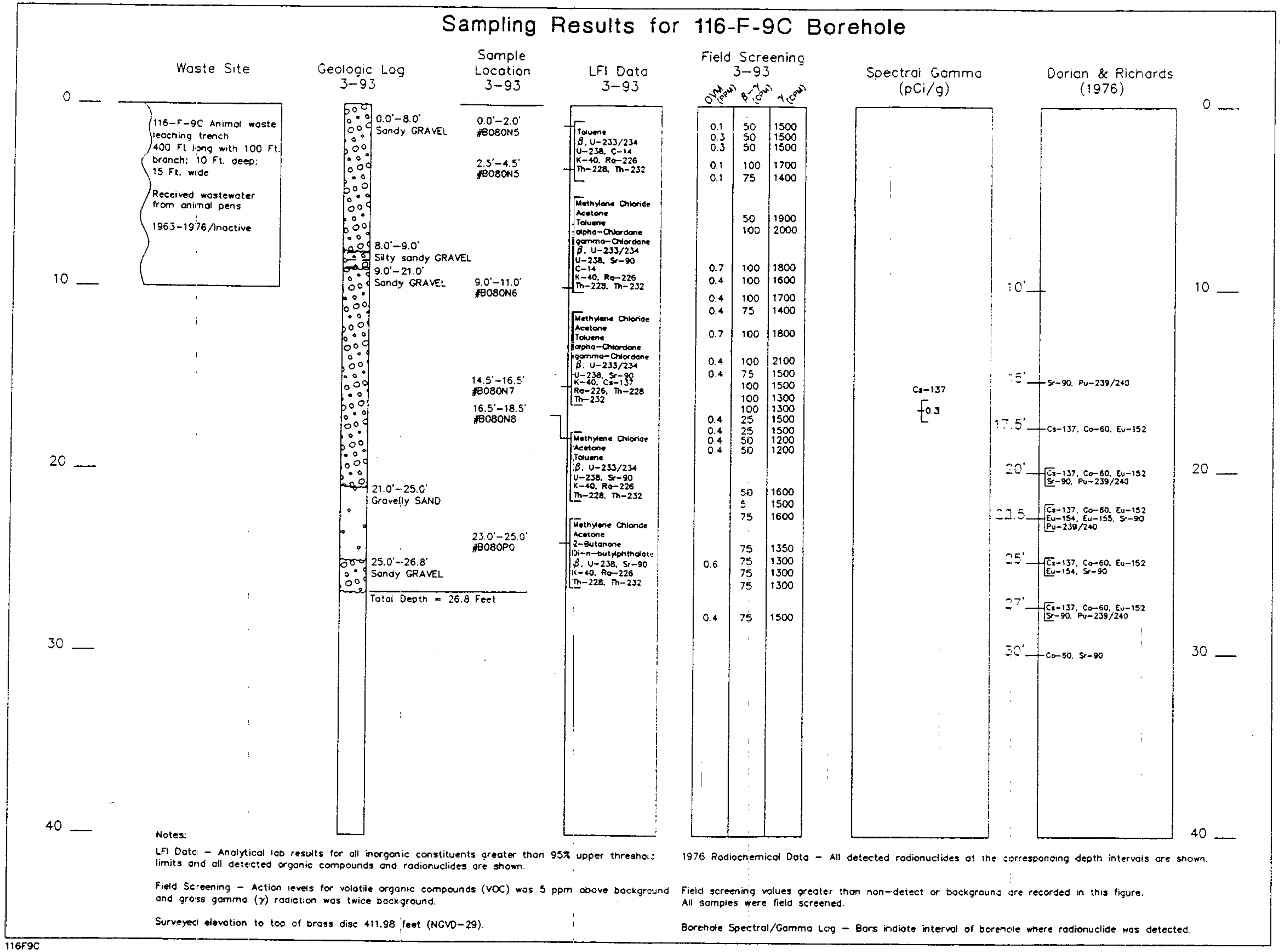

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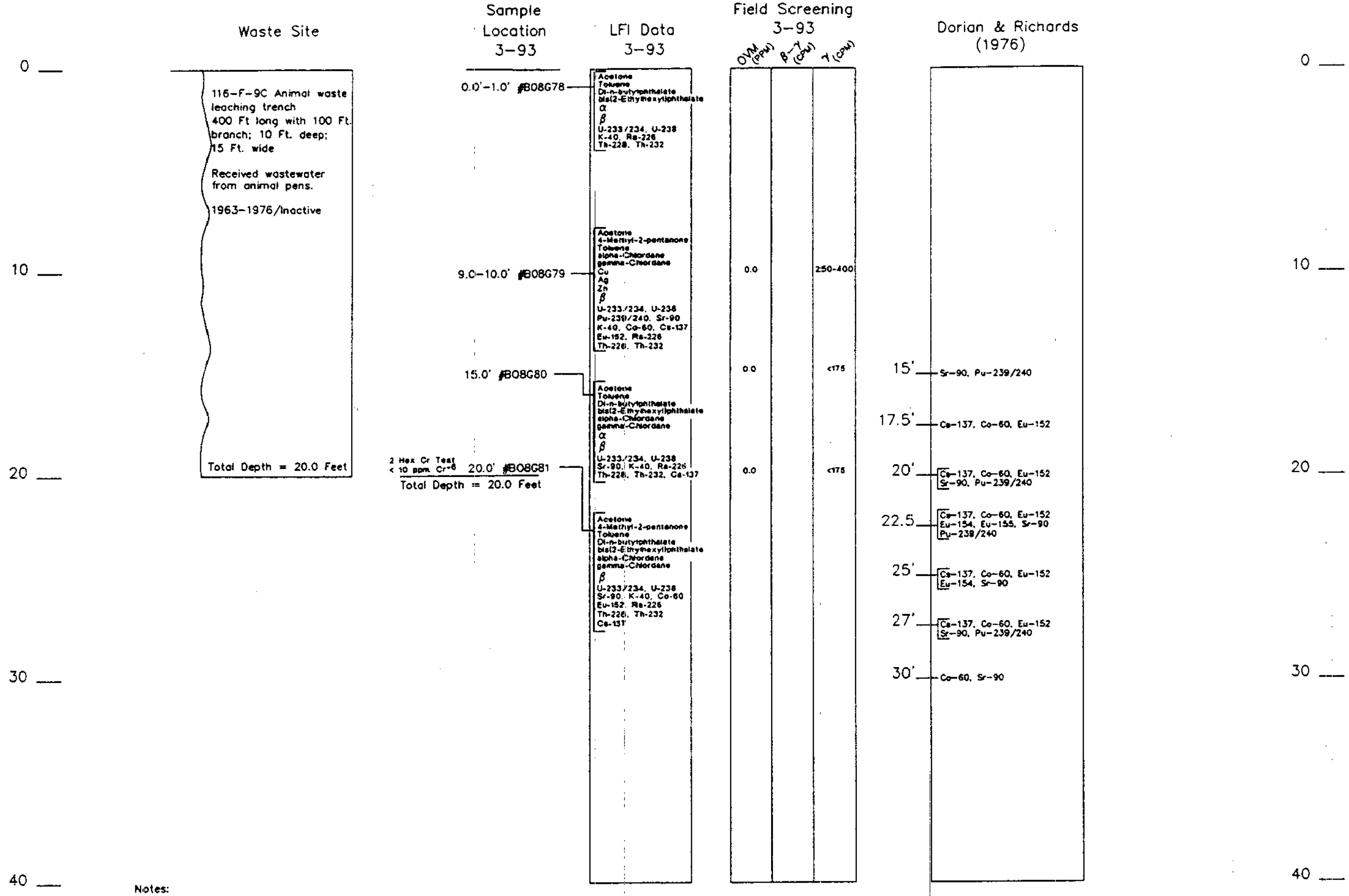
Figure 3-14 Summary Diag
of the 116-F-9D LFI Test Pit I

Sampling Results for 116-F-9D Test Pit



Notes:

LFI Data – Analytical lab results for all inorganic constituents greater than 95% upper threshold limits and all detected organic compounds and radionuclides are shown.

Field Screening – Action levels for volatile organic compounds (VOC) was 5 ppm and gross gamma (γ) radiation was twice background.

1976 Radiochemical Data – All detected radionuclides at the corresponding depth intervals are shown.

Field screening values greater than non-detect or background are recorded in this figure. All samples were field screened.

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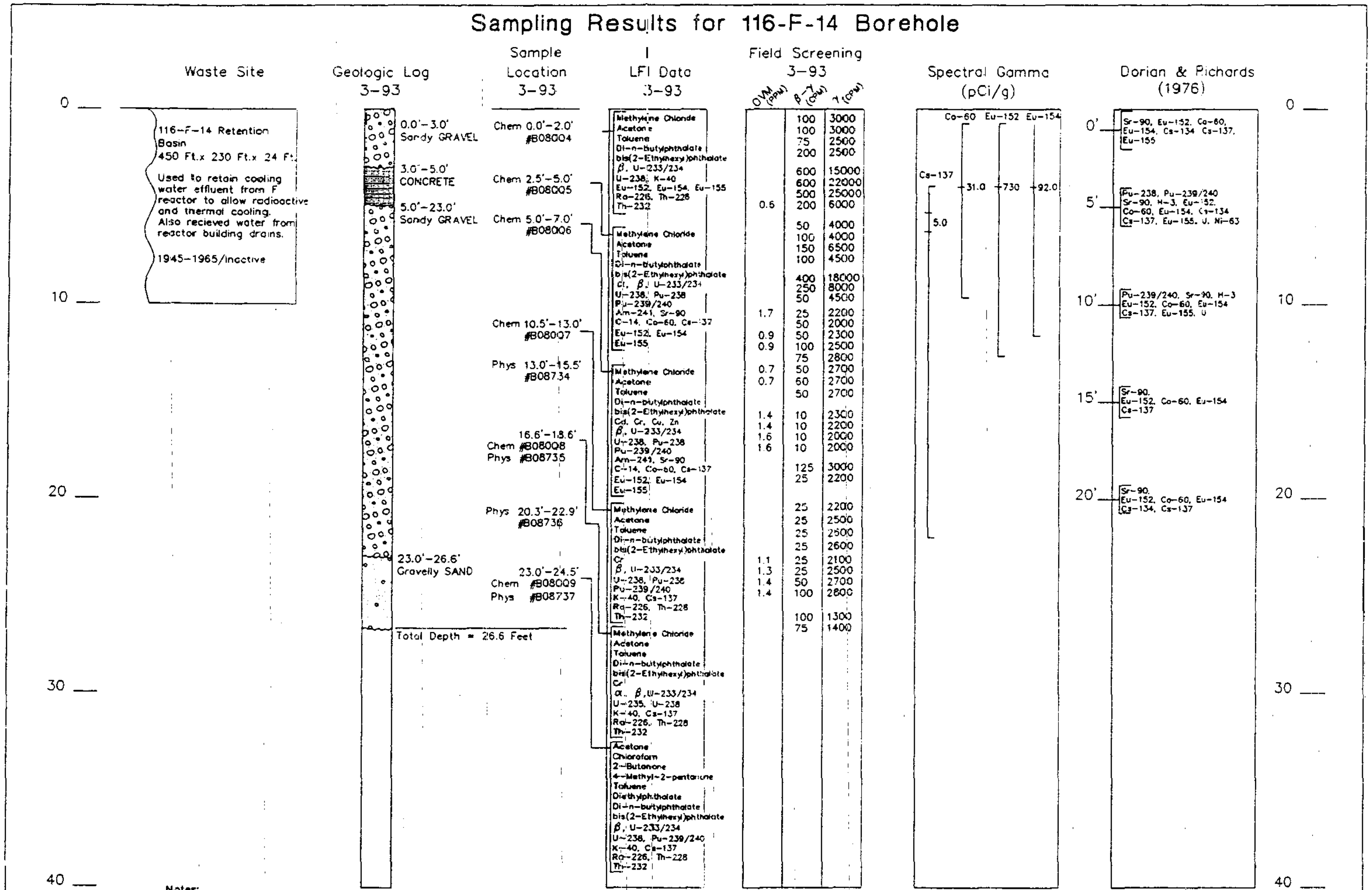
Figure 3-15 Summary Diagr
of the 116-F-14 LFI Borehole D



Notes:

LFI Data – Analytical lab results for all inorganic constituents greater than 95% upper threshold limits and all detected organic compounds and radionuclides are shown.

Field Screening – Action levels for volatile organic compounds (VOC) was 5 ppm above background and gross gamma (γ) radiation was twice background.

Surveyed elevation to top of brass disc 403.78 feet (NGVD-29).

1976 Radiochemical Data – All detected radionuclides at 5 ft. depth intervals are shown. See Appendix B for a complete reporting.

Field screening values greater than non-detect or background are recorded in this figure. All samples were field screened.

Borehole Spectral/Gamma Log – Bars indiate interval of borehole where radionuclide was detected.

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Table 3-2 Analytical Results for the 116-F-1B Test Pit (page 2 of 2)

Sample Number	B08G65	B08G66	B08G67	B08G68	95% UTL (b)	CRQL/CRDL
Depth Interval	1 ft	5 ft	10 ft	15 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Radium-226	0.49	0.51	0.45[J]	0.38	NR	NR
Thorium-228	0.97[J]	0.70[J]	0.76[J]	0.69[J]	NR	NR
Thorium-232	0.69[J]	0.79[J]	0.58[J]	0.56[J]	NR	NR
Uranium-233/234	0.51	0.39	0.35	0.41	NR	NR
Uranium-238	0.44	0.50	0.59	0.43	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.5	0.8	0.7	0.7	12	NR
NO_3, NO_2	4.45	ND	ND	ND	199 (c)	NR
pH (a)	9.3	8.6	8.9	9.0	NR	NR
Sulfate	4	71	95	18	1,320	NR

a = Reported as standard units.
b = 95% confidence limit of the 95th percentile of the data distribution.
c = Value reported is for Nitrate only.
J = Estimated value.
NA = Not analyzed.
ND = Not detected.
NR = Not reported.

Table 3-2 Analytical Results for the 116-F-1B Test Pit (page 1 of 2)

Sample Number / Depth Interval	B08G65 / 1 ft	B08G66 / 5 ft	B08G67 / 10 ft	B08G68 / 15 ft	95% UTL (b)	CRQL/CRDL
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	6,120	5,800	6,060	6,190	15,600	200
Arsenic	2.6	2.0	2.8	2.7	8.92	10
Barium	77.9	49.6	59.2	56.9	171	200
Beryllium	0.24	0.25	0.23	0.25	1.77	5
Calcium	4,130	5,150	5,210	4,430	23,920	5,000
Chromium	14.7	9.8	12.1	10.2	27.9	10
Cobalt	6.6	5.9	6.4	7.1	19.6	50
Copper	14.4	16.0	16.4	15.5	28.2	25
Iron	13,800	12,900	13,200	14,000	39,160	100
Lead	13.1	5.8	8.1	5.0	14.75	3
Magnesium	3,990	3,810	4,020	4,060	8,760	5,000
Manganese	236	200	305	294	612	15
Mercury	0.18	0.35	0.56	0.26	1.25	0.2
Nickel	9.1	9.5	11.7	10.4	25.3	40
Potassium	1,530	581	736	760	3,120	5,000
Silver	ND	0.71	ND	0.98	2.7	10
Sodium	136	152	143	146	1,290	5,000
Vanadium	32.4	31.1	29.6	32.9	111	50
Zinc	37.0	36.3	43.5	32.1	79	20
Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
2-Hexanone	ND	ND	ND	2J	NR	10
4-Methyl-2-pentanone	ND	ND	ND	1J	NR	10
Acetone	11	6J	ND	13	NR	10
Methylene Chloride	ND	2J	ND	ND	NR	10
Toluene	42	5J	33	13	NR	10
Semi Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
bis(2-Ethylhexyl)phthalate	48J	40J	54J	ND	NR	330
Di-n-butylphthalate	55J	52J	52J	41J	NR	330
Pesticides/PCB	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
	ND	ND	ND	ND	NR	ND
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	12	7J	8.7J	7J	NR	NR
gross beta	14	16	16	16	NR	NR
Potassium-40	14	13	14	13	NR	NR
Cesium-137	0.19J	0.11J	0.081J	ND	NR	NR

Table 3-1 Analytical Results for the 116-F-1A Borehole (page 2 of 2)

Sample Number	B08ON1	B08ON2	B08ON3	B08ON4	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	9.5-11 ft	14.5-16.2 ft	18-20 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Uranium-233/234	0.53	0.34	0.94	0.43	NR	NR
Uranium-238	0.77	0.39	0.83	0.41	NR	NR
Plutonium-239/240	0.016J	ND	ND	ND	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.8	0.8	0.6	0.4	12	NR
NO_3, NO_2	5.97	ND	ND	ND	199 (b)	NR
Sulfate	9	11	12	12	1,320	NR

a = 95% confidence limit of the 95th percentile of the data distribution.
b = Value reported is for Nitrate only.
J = Estimated value.
ND = Not detected.
NA = Not analyzed.
NR = Not reported.

Table 3-1 Analytical Results for the 116-F-1A Borehole (page 1 of 2)

Sample Number	B080N1	B080N2	B080N3	B080N4	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	9.5-11 ft	14.5-16.2 ft	18-20 ft		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	7,500	4,760	4,420	4,580	15,600	200
Arsenic	44	1.1	1.1	1.3	8.92	10
Barium	72.8	44.8	60.2	45.8	171	200
Beryllium	0.29	0.25	0.22	0.21	1.77	5
Calcium	3,430	3,490	4,870	2,870	23,920	5,000
Chromium	19.1	9.6	8.1	7.7	27.9	10
Cobalt	8.1	8.2	7.6	6.6	19.6	50
Copper	13.5	15.7	13.9	12.8	28.2	25
Iron	16,100	14,600	13,700	12,100	39,160	100
Lead	207	2.4	1.6	2.2	14.75	3
Magnesium	3,900	3,320	3,290	3,440	8,760	5,000
Manganese	278	235	201	204	612	15
Mercury	0.08	ND	ND	ND	1.25	0.2
Nickel	10.9	7.6	8	8.3	25.3	40
Potassium	1,860	744	788	581	3,120	5,000
Sodium	125	292	311	238	1,290	5,000
Vanadium	33.3	40.8	37.3	29.2	111	50
Zinc	44.7	32.7	29.2	31.3	79	20
Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Acetone	ND	ND	ND	10[J]	NR	10
Methylene Chloride	3[J]	ND	3[J]	ND	NR	10
Toluene	6[J]	3[J]	11	36	NR	10
Semi Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
bis(2-Ethylhexyl)phthalate	360[J]	ND	ND	NA	NR	330
Di-n-butylphthalate	120[J]	130[J]	150[J]	NA	NR	330
Pesticides/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
	ND	ND	ND	NA	NR	ND
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	5.5[J]	ND	ND	ND	NR	NR
gross beta	21	14	13	15	NR	NR
Carbon-14	190	220	180	160	NR	NR
Potassium-40	12	11	11	11	NR	NR
Cesium-137	0.056	ND	ND	ND	NR	NR
Europium-152	0.23[J]	ND	ND	ND	NR	NR
Radium-226	0.4	0.43	0.41	0.29	NR	NR
Thorium-228	0.6	0.44	0.51	0.45	NR	NR
Thorium-232	0.63	0.42	0.53	0.35	NR	NR

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Table 3-3 Analytical Results for the 116-F-1C Test Pit (page 1 of 3)

Sample Number	B0SG69	B0SG70	B0SG71	B0SG72	B0SG73	B0SG74	B0SG75	B0SG76	B0SG77	95% UTL (b)	CRQL/ CRDL
Depth Interval	Field Bank	Surface	Split	Duplicate	5 ft	10 ft	15 ft	20 ft	Trip Bank		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	49.4	6,810	4,560	6,170	4,450	4,700	5,040	4,550	NA	15,600	200
Arsenic	ND	3	2.4	2.8	1.6	1.2	2.1	1.7	NA	8.92	10
Barium	0.45	70.3	54.6	65	42	28.3	48.1	33.2	NA	171	200
Beryllium	ND	0.25	ND	0.22	0.12	0.15	0.14	0.23	NA	1.77	5
Cadmium	ND	0.65	ND	0.58	ND	ND	ND	ND	NA	0.66 (c)	5
Calcium	ND	3,030	2,400	2,760	2,470	2,580	2,720	3,160	NA	23,920	5,000
Chromium	ND	23.3	18.9	22.3	7.3	8.7	9.5	6.6	NA	27.9	10
Cobalt	ND	8.6	6.2	7.3	6.2	6.2	6.5	5.3	NA	19.6	50
Copper	1.1	21.5	16.6	20.2	13.3	13.9	13.2	17.4	NA	28.2	25
Iron	195	16,300	10,500	14,500	11,500	11,600	11,700	10,600	NA	39,160	100
Lead	0.30	11.5	9.8	13.8	3.5	2.6	4	3.2	NA	14.75	3
Magnesium	9	4,330	3,140	3,860	3,340	3,570	3,860	3,380	NA	8,760	5,000
Manganese	0.82	223	176	213	213	199	204	203	NA	612	15
Mercury	0.08	0.57	ND	0.69	0.06	0.09	0.14	0.10	NA	1.25	0.2
Nickel	ND	13	10	10.5	9.5	10.6	11.5	6.8	NA	25.3	40
Potassium	ND	872	730	828	453	443	518	529	NA	3,120	5,000
Silver	ND	1.3	ND	1	ND	0.91	0.73	ND	NA	2.7	10
Sodium	17	130	88.9	117	116	140	148	118	NA	1,290	5,000
Vanadium	ND	39	17	32.5	28.1	28.4	27.5	23.2	NA	111	50
Zinc	ND	142	132	133	24.9	25.4	28.7	23.3	NA	79	20
Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
2-Butanone	ND	ND	ND	6J	ND	ND	ND	ND	ND	NR	10
2-Hexanone	ND	ND	ND	3J	ND	ND	ND	ND	ND	NR	10
4-Methyl-2-pentanone	ND	ND	ND	2J	ND	ND	ND	ND	1J	NR	10
Acetone	8J	ND	15	9J	7J	9J	7J	9J	7J	NR	10
Methylene chloride	ND	ND	12	ND	ND	ND	ND	ND	ND	NR	10
Tetrachloroethene	ND	ND	1J	ND	ND	ND	ND	ND	ND	NR	10

Table 3-3 Analytical Results for the 116-F-1C Test Pit (page 2 of 3)

Sample Number	B08G69	B08G70	B08G71	B08G72	B08G73	B08G74	B08G75	B08G76	B08G77	95% UTL (b)	CRQL/ CRDL
Depth Interval	Field Bank	Surface	Split	Duplicate	5 ft	10 ft	15 ft	20 ft	Trip Bank		
Volatile Organics (cont'd)	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
Toluene	3J	8J	23	57	ND	2J	2J	4J	ND	NR	10
Trichloroethene	ND	ND	1J	ND	ND	ND	ND	ND	ND	NR	10
Semi Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
bis(2-Ethylhexyl)phthalate	ND	36J	470	44J	190J	53J	73J	ND	NA	NR	330
Di-n-butylphthalate	42J	52J	30J	58J	69J	58J	57J	47J	NA	NR	330
Pesticides/PCB	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
	ND	ND	ND	ND	ND	ND	ND	ND	NA	NR	ND
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	ND	9.5J	7.5	14	ND	ND	ND	6.4J	NA	NR	NR
gross beta	ND	17	35	16	16	13	17	19	NA	NR	NR
Potassium-40	0.38	13	13.5	13	14	13	11	14	NA	NR	NR
Strontium-90	ND	ND	0.13	ND	ND	ND	ND	ND	NA	NR	NR
Cesium-137	ND	ND	0.0404	0.088J	ND	ND	ND	ND	NA	NR	NR
Radium-226	0.076	0.65	ND	0.65	0.38	0.39	0.32	0.46	NA	NR	NR
Thorium-228	0.15J	1J	0.587	0.76J	0.46J	0.73J	0.48J	0.56J	NA	NR	NR
Thorium-232	0.18J	0.89J	ND	0.94J	0.69J	0.58J	0.52J	0.54J	NA	NR	NR
Uranium-233/234	0.098J	0.40	ND	0.71	0.53	0.44	0.30	0.35	NA	NR	NR
Uranium-235	ND	ND	0.0073	0.15	ND	ND	ND	ND	NA	NR	NR
Uranium-238	0.063J	0.36	0.24	0.73	0.48	0.44	0.31	0.41	NA	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.4	0.8	4.1	0.8	0.4	0.6	0.9	0.5	NA	12	NR
Nitrate	ND	ND	2.9	ND	ND	ND	ND	ND	NA	199	NR
NO_3, NO_2	ND	ND	ND	4.12	ND	ND	ND	ND	NA	199 (c)	NR
pH (a)	7.4	8.2	ND	8.1	7.5	8.1	9	9.4	NA	NR	NR
Sulfate	4	3	2.6	3	4	3	6	11	NA	1,320	NR

Table 3-3 Analytical Results for the 116-F-1C Test Pit (page 3 of 3)

Sample Number	B08G69	B08G70	B08G71	B08G72	B08G73	B08G74	B08G75	B08G76	B08G77	95% UTL (b)	CRQL/ CRDL
Depth Interval	Field Bank	Surface	Split	Duplicate	5 ft	10 ft	15 ft	20 ft	Trip Bank		

a - Reported as standard units.
b - 95% confidence limit of the 95th percentile of the data distribution
c - Value reported for Nitrate only.
J - Estimated value
NA - Not analyzed.
ND - Not detected.
NR - Not reported.

Table 3-4 Analytical Results for the 116-F-2 Borehole (page 1 of 2)

Sample Number	B080M4	B080M6	B080M7	B080M8	B080M9	B080N0	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	10-12 ft	14.8-16.8 ft ft	19.7-26.7 ft	24.6-26.6 ft	30-32 ft		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	5,630	5,430	5,230	4,730	5,440	5,450	15,600	200
Arsenic	2.1	0.85	0.76	ND	0.94	1.5	8.92	10
Barium	51.7	79.1	48	338	67.4	47.9	171	200
Beryllium	0.28	0.31	0.23	0.21	0.20	0.19	1.77	5
Cadmium	ND	1.6	0.33	ND	ND	ND	0.66 (b)	5
Calcium	5,000	4,010	3,580	5,600	4,490	2,610	23,920	5,000
Chromium	11	98.1	30.5	14.4	18.3	20.5	27.9	10
Cobalt	7.4	9.3	7.3	7.5	8.5	6.5	19.6	50
Copper	13.5	22	13.6	13.2	12.5	12.9	28.2	25
Iron	14,700	17,000	13,900	13,300	14,500	12,200	39,160	100
Lead	3.8ʴ	12.9ʴ	3.6ʴ	2.6ʴ	2.5ʴ	3.3	14.75	3
Magnesium	3,830	3,770	3,980	3,620	4,150	3,960	8,760	5,000
Manganese	253	239	231	318	215	240	612	15
Mercury	ND	0.96	0.23	0.16	ND	ND	1.25	0.2
Nickel	9.6	11.1	10.5	8	11.4	9.8	25.3	40
Potassium	970	771	696	604	668	528	3,120	5,000
Sodium	157	248	238	241	296	126	1,290	5,000
Vanadium	34	40.4	33.2	32.5	39.5	29.2	111	50
Zinc	34.1	295	54.6	33.5	32.1	28.7	79	20
Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Methylene Chloride	ND	ND	ND	ND	ND	2ʴ	NR	10
Toluene	ND	ND	ND	ND	ND	4ʴ	NR	10
Semi Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Benzo(b)fluoranthene	ND	83ʴ	ND	ND	ND	ND	NR	330
Chrysene	ND	48ʴ	ND	ND	ND	ND	NR	330
Di-n-butylphthalate	ND	ND	ND	ND	ND	71ʴ	NR	330
Pesticides/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
	ND	ND	ND	ND	ND	ND	NR	ND
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	ND	11	ND	10	ND	4.6ʴ	NR	NR
gross beta	16	350	140	85	14	16	NR	NR
Carbon-14	62	230	240	230	230	230	NR	NR
Potassium-40	13	ND	21	16	10	9.5	NR	NR
Cobalt-58	NA	NA	0.67	NA	NA	NA	NR	NR
Cobalt-60	0.041ʴ	12ʴ	6.8ʴ	3.5ʴ	ND	ND	NR	NR
Strontium-90	ND	7.6	3.2	1.3ʴ	ND	ND	NR	NR
Cesium-137	0.21	35	31	22	2.9	0.66	NR	NR

Table 3-4 Analytical Results for the 116-F-2 Borehole (page 2 of 2)

Sample Number	B080M4	B080M6	B080M7	B080M8	B080M9	B080N0	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	10-12 ft	14.8-16.8 ft ft	19.7-26.7 ft	24.5-26.5 ft	30-32 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Europium-152	5.3[J]	550[J]	190[J]	77[J]	0.21[J]	0.17[J]	NR	NR
Europium-154	0.27	360	17	8.7	ND	ND	NR	NR
Europium-155	NA	NA	0.65	0.41	NA	NA	NR	NR
Iridium-192	NA	0.58	NA	NA	NA	NA	NR	NR
Radium-226	0.52	ND	0.33	0.58	0.39	0.30	NR	NR
Thorium-228	0.99	ND	0.65	1	0.33	0.59	NR	NR
Thorium-232	0.56	ND	ND	ND	0.45	0.51	NR	NR
Uranium-233/234	0.35	0.47	0.37	0.44	0.50	0.35	NR	NR
Uranium-235	ND	0.13[J]	ND	ND	0.37	ND	NR	NR
Uranium-238	0.43	0.59	0.58	0.37	0.60	0.47	NR	NR
Plutonium-238	ND	0.068	0.022[J]	ND	ND	ND	NR	NR
Plutonium-239/240	ND	3.7	1.3	0.28	ND	ND	NR	NR
Americium-241	ND	0.57	0.25[R]	0.088	ND	ND	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.50	0.60	0.50	0.50	0.60	0.40	12	NR
NO_3, NO_2	ND	6.16	3.61	ND	2.71	2.62	199 (c)	NR
Sulfate	9	17	11	15	10	5	1,320	NR

a = 95% confidence limit of the 95th percentile of the data distribution.
b = Value reported is limit of detection.
c = Value reported is for Nitrate only.
J = Estimated value.
R = Value marked as rejected in validation report.
ND = Not detected.
NA = Not analyzed.
NR = Not reported.

Table 3-5 Analogous Site Comparison for 116-F-2 (page 1 of 2)

Maximum Concentration	116-F-2	116-B-1	116-DR-1	116-DR-2	116-H-1	95% UTL (d)	CRQL/CRDL
INORGANICS (a)	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Arsenic	-	-	-	-	37.9	8.92	10
Barium	338	-	-	-	-	171	200
Cadmium	1.6	-	-	1.10J	-	0.66(e)	5
Chromium	98.1	33	186J	-	29.6	27.9	10
Lead	-	-	-	-	187	14.75	3
Manganese	-	839	-	-	-	612	15
Silver	-	-	3.50N	3.70N	-	2.7	10
Zinc	295	128	109J	-	-	79	20
VOLATILE ORGANICS	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Acetone	-	-	-	22	-	NR	10
Methylene Chloride	2J	-	1J	9	11	NR	10
Toluene	4J	-	3J	-	14	NR	10
SEMI VOLATILE ORGANICS	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
1,3-Dichlorobenzene	-	-	48J	-	-	NR	330
1,4-Dichlorobenzene	-	-	37J	-	-	NR	330
2-Chlorophenol	-	-	47J	-	-	NR	330
2-Methylnaphthalene	-	-	-	-	42J	NR	330
4-Chloro-3-methylphenol	-	-	38J	-	-	NR	330
Acenaphthene	-	-	-	-	210J	NR	330
Anthracene	-	-	-	-	430J	NR	330
Benzo(a)anthracene	-	-	-	-	940J	NR	330
Benzo(a)pyrene	-	-	-	-	810J	NR	330
Benzo(b)fluoranthene	83J	-	-	-	890J	NR	330
Benzo(ghi)perylene	-		-	-	410J	NR	330
Benzo(k)fluoranthene	-	-	-	-	780J	NR	330
Benzoic acid	-	-	250J	-	-	NR	-
Chrysene	48J	-	-	-	920J	NR	330
Dibenzofuran	-	-	-	-	130J	NR	330
Di-n-butylphthalate	71J	-	-	35J	68J	NR	330
Fluoranthene	-	-	-	-	1800J	NR	330
Fluorene	-	-	-	-	190J	NR	330
Indeno(1,2,3-cd)pyrene	-	-	-	-	520J	NR	330
Phenanthrene	-	-	-	-	1500J	NR	330
Pyrene	-	-	-	-	1200J	NR	330
RADIONUCLIDES (b)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Carbon-14	240	6.18J	-	-	-	NR	-
Sodium-22	-	-	9.91J	-	-	NR	-

Table 3-5 Analogous Site Comparison for 116-F-2 (page 2 of 2)

MAXIMUM CONCENTRATION	116-F-2	116-B-1	116-DR-1	116-DR-2	116-H-1	95% UTL (d)	CRQL/CRDL
RADIONUCLIDES (b) (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Potassium-40	21	-	20J	10J	-	NR	-
Cobalt-60	12J	4.167	23.1J	3.75J	2.5	NR	-
Strontium-90	7.6	13.2e	10J	1.7	6.2	NR	-
Cesium-137	35	43.85	147J	233J	32	NR	-
Europium-152	550J	121.9	258J	24J	54	NR	-
Europium-154	360	9.9	25.7	2.53J	5.4	NR	-
Thorium-228	1	-	-	-	-	NR	-
Plutonium-239/240	3.7	3.6 (c)	-	14J	-	NR	-

a = Inorganic values were screened against Hanford Site background 95% UTL, Region X excluded elements.
b = Only radionuclides greater than 1 pCi/g were reported.
c = Value for Plutonium 239 only.
d = 95% confidence limit of the 95th percentile of the data distribution.
e = Value reported is limit of detection.
J = Value is estimated, concentration less than contract required detection limit.
R = Value marked as rejected in validation report.
\- = Not detected.
NR = Not reported.
Analogous site data taken from associate LFI reports, (DOE-RL 1993b), (DOE-RL 1993c), (DOE-RL 1993d).

Table 3-6 Analytical Results for the 116-F-3 Test Pit (page 1 of 2)

Sample Number	B08G82	B08G83	B08G84	B08G86	95% UTL (b)	CRQL/ CRDL
Depth Interval	Surface	7 ft	12 ft	17 ft		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	7,740	7,250	4,900	4,620	1,560	200
Arsenic	1	3.1	2.3	1.8	8.92	10
Barium	378	79.6	35.7	52.3	171	200
Beryllium	0.46	0.27	0.34	0.43	1.77	5
Calcium	11,500	6,180	5,070	5,570	23,920	5,000
Chromium	5.5	74.4	8.7	7.9	27.9	10
Cobalt	7.8	8.5	5.4	5.8	19.6	50
Copper	22.2	23.8	11.1	11.1	28.2	25
Iron	12,200	19,500	10,900	10,700	39,160	100
Lead	18.2	49.9	2.8	2.8	14.75	3
Magnesium	4,590	4,010	3,830	3,530	8,760	5,000
Manganese	187	297	215	246	612	15
Mercury	0.12	1.5	ND	ND	1.25	0.2
Nickel	9.8	11.3	10	8.6	25.3	40
Potassium	979	1,290	587	568	3,120	5,000
Silver	ND	1.3	ND	ND	2.7	10
Sodium	648	219	137	144	1,290	5,000
Vanadium	30.2	36.3	27	25.3	111	50
Zinc	53.3	175	24.4	24.5	79	20
Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
4-Methyl-2-pentanone	ND	11J	ND	ND	NR	10
Acetone	ND	6J	10J	9J	NR	10
Toluene	21	ND	ND	7J	NR	10
Semi Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Benzo(a)anthracene	240J	ND	ND	ND	NR	330
Benzo(b)fluoranthene	220J	ND	ND	ND	NR	330
bis(2-Ethylhexyl)phthalate	ND	43J	ND	45J	NR	330
Chrysene	280J	ND	ND	ND	NR	330
Di-n-butylphthalate	ND	77J	56J	77J	NR	330
Fluoranthene	440J	ND	ND	ND	NR	330
Phenanthrene	270J	ND	ND	ND	NR	330
Pyrene	440J	ND	ND	ND	NR	330
Pesticides/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Aroclor-1254	ND	180	ND	ND	NR	33
Toxaphene	ND	190	ND	ND	NR	170
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pC[illegible]
gross alpha	6.7J(6.4)	7.1J	7.9J	7.4J	NR	[illegible]

Table 3-6 Analytical Results for the 116-F-3 Test Pit (page 2 of 2)

Sample Number	B08G82	B08G83	B08G84	B08G85	95% UTL (b)	CRQL/ CRDL
Depth Interval	Surface	7 ft	12 ft	17 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross beta	11	71	22	22	NR	NR
Potassium-40	7.9	23	15	13	NR	NR
Cobalt-60	0.058	1.9	ND	ND	NR	NR
Cesium-137	0.52J	2.6J	ND	ND	NR	NR
Europium-152	0.11	190	0.82	0.28	NR	NR
Europium-154	0.075J	9.8	ND	ND	NR	NR
Radium-226	0.50	0.43	0.55	0.38	NR	NR
Thorium-228	0.65J	0.79J	0.92	0.68	NR	NR
Thorium-232	0.69J	ND	0.63	0.56	NR	NR
Uranium-233/234	0.51	0.44	0.68	0.46	NR	NR
Uranium-235	ND	0.055J	ND	ND	NR	NR
Uranium-238	0.36	0.46	0.58	0.69	NR	NR
Plutonium-238	-0.046R	ND	ND	ND	NR	NR
Plutonium-239/240	0.012R	0.46	0.95J	ND	NR	NR
Americium-241	ND	0.033J	ND	ND	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/Kg
Fluoride	0.50	0.70	0.40	0.80	12	NR
NO_3, NO_2	11.2	11.5	ND	ND	199 (c)	NR
pH (a)	8.8	8.7	9.4	9.4	1,320	NR
Sulfate	11	26	12	32		

a = Reported as standard units.
b = 95% confidence limit of the 95th percentile of the data distribution.
c = Value reported for Nitrate only.
J = Estimated value.
R = Value marked as rejected in validation report.
NA = Not analyzed.
ND = Not detected.
NR = Not reported.

Table 3-7 Analogous Site Comparison for 116-F-3 (page 1 of 2)

MAXIMUM CONCENTRATION	116-F-3	116-B-2	116-D-1a	116-D-1b	95% UTL (c)	CRQL/CRDL
INORGANICS (a)	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Barium	378	-	-	-	171	200
Cadmium	-	-	1	-	0.66 (d)	5
Chromium	74.4	-	108	30.4	27.9	10
Lead	49.9	-	51.9	22	14.79	3
Mercury	1.5	-	-	-	1.25	0.2
Nickel	-	-	42.5	-	25.3	40
Zinc	175	-	-	106	79	20
VOLATILE ORGANICS	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
4-Methyl-2-pentanone	11[J]	11	-	-	NR	10
Acetone	10[J]	-	-	41[J]	NR	10
Methylene Chloride	-	-	-	11[J]	NR	10
Toluene	21	52	-	1[J]	NR	10
SEMI VOLATILE ORGANICS	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
1,3-Dichlorobenzene	-	-	38[J]	-	NR	330
Benzo(a)anthracene	240[J]	-	-	-	NR	330
Benzo(b)fluoranthene	220[J]	-	-	-	NR	330
bis(2-ethylhexyl)phthalate	43[J]	-	350[J]	-	NR	330
Carbazole	-	-	52[J]	54[J]	NR	330
Chrysene	280[J]	-	-	58[J]	NR	330
Di-n-butylphthalate	77[J]	-	77[J]	35[J]	NR	330
Fluoranthene	440[J]	-	-	-	NR	330
N-Nitrosodiphenylamine	-	110[J]	-	-	NR	330
Phenanthrene	270[J]	-	-	-	NR	330
Pyrene	440[J]	39[J]	-	-	NR	330
PESTICIDES/PCB	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
Aldrin	-	-	-	7.5[J]	NR	1.7
Arochlor-1254	180	-	-	-	NR	33
beta-BHC	-	-	7.8[J]	-	NR	1.7
Toxaphene	190	-	-	-	NR	170
RADIONUCLIDES (b)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Carbon-14	-	3.95[J]	-	-	NR	-
Sodium-22	-	-	-	5.7[J]	NR	-
Potassium-40	23		13.4[J]	14.1[J]	NR	-
Cobalt-60	1.9	-	10.9[J]	16.3[J]	NR	-
Strontium-90	-	64.1	5[J]	32	NR	-
Cesium-137	2.6[J]	91.32	305[J]	322[J]	NR	-

Table 3-7 Analogous Site Comparison for 116-F-3 (page 2 of 2)

MAXIMUM CONCENTRATION	116-F-3	116-B-2	116-D-1a	116-D-1b	95% UTL (c)	CRQL/CRDL
RADIONUCLIDES (b) (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Europium-152	190	10.36	112[J]	147[J]	NR	-
Europium-154	9.8	-	62.5[J]	98.2[J]	NR	-
Radium-226	-	-	42.8[J]	-	NR	-
Plutonium-239	-	5.71[R]	8.3[J]	5.3[J]	NR	-
Americium-241	-	-	1.4[R]	1.3[R]	NR	-

a = Inorganic values were screened against Hanford Site background 95% UTL, Region X excluded elements.
b = Only radionuclides greater than 1 pCi/g were reported.
c = 95% confidence limit of the 95th percentile of the data distribution.
d = Value reported is limit of detection.
J = Value is estimated, concentration less than contract required detection limit.
R = Value marked as rejected in validation report.
- = Not detected.
NR = Not reported.
Analogous site data taken from associate LFI reports, (DOE-RL 1993b), (DOE-RL 1993c), (DOE-RL 1993d).

Table 3-8 Analytical Results for the 116-F-4 Borehole (page 1 of 2)

Sample Number	B080P2	B080P3	B080P4	B080P6	B080P9	B080Q3	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	6-7 ft	9.4-11.4 ft	13.4-15.6 ft	19-20.8 ft	25-26.8 ft		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	7,390	7,320	4,640	5,000	5,310	4,070	15,600	200
Arsenic	2.3	1.6	0.99^{J}	1.1	1.2	1.2	6.92	10
Barium	190	208	53.3	49.6	48.6	46.9	171	200
Beryllium	0.27	0.32	0.19	0.2	ND	0.21	1.77	5
Calcium	9,260	8,440	4,870	5,150	5,830	5,260	23,920	5,000
Chromium	10	10.5	9.6	9.4	12.9	14.6	27.9	10
Cobalt	7.3	8.5	8.6	8.1	6.2	8	19.6	50
Copper	16	18.3	14.1	12.2	11.7	13.4	28.2	25
Iron	14,300	16,400	15,400	15,600	13,100	14,900	39,160	100
Lead	8.8	10.2	2.4	2.5	2.9	2.7	14.75	3
Magnesium	4,740	4,450	3,870	3,720	3,920	3,020	8,760	5,000
Manganese	255	249	249	247	236	327	612	15
Mercury	ND	0.06	ND	ND	ND	ND	1.25	0.2
Nickel	11.1	10.3	8.2	7.8	10.3	9.9	25.3	40
Potassium	1,060	954	624	824	989	672	3,120	5,000
Silver	0.89	0.94	0.88	ND	ND	ND	2.7	10
Sodium	303	430	289	371	273	386	1,290	5,000
Vanadium	33.3	40.3	38.7	44.7	34.4	39	111	50
Zinc	37.6	39.3	34.6	34.8	36.1	28.6	79	20
Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
2-Butanone	22	NR	ND	ND	ND	ND	NR	10
Acetone	14	NR	ND	ND	11	8^{J}	NR	10
Methylene Chloride	5^{J}	NR	ND	3^{J}	3^{J}	4^{J}	NR	10
Toluene	8^{J}	NR	13	4^{J}	3^{J}	1^{J}	NR	10
Semi Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
bis(2-Ethylhexyl)phthalate	800	NA	ND	140^{J}	96^{J}	ND	NR	330
Di-n-butylphthalate	ND	NA	ND	130^{J}	280^{J}	130^{J}	NR	330
Di-n-octylphthalate	ND	NA	ND	170^{J}	ND	ND	NR	330
Pesticides/PCB	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
	ND	NA	ND	ND	ND	ND	NR	ND
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	ND	14^{J}	96^{J}	ND	ND	ND	NR	NR
gross beta	20	440^{J}	$4,900^{J}$	1,400	14	12	NR	NR
Potassium-40	9.2^{J}	10^{J}	11^{J}	12	7.5	11	NR	NR
Cobalt-60	ND	0.14	0.34	ND	ND	ND	NR	NR
Strontium-90	5.2	160	1,500	570^{J}	ND	ND	NR	NR

Table 3-8 Analytical Results for the 116-F-4 Borehole (page 2 of 2)

Sample Number	B080P2	B080P3	B080P4	B080P5	B080P9	B080Q3	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	5-7 ft	9.4-11.4 ft	13.4-15.6 ft	19-20.8 ft	25-26.8 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Cesium-137	3.5	340	1,800	920	0.72R	ND	NR	NR
Europium-152	ND	3.1	16	8.6	ND	ND	NR	NR
Europium-154	ND	0.3	NA	0.83J	ND	ND	NR	NR
Radium-226	0.51J	0.45J	0.66J	ND	0.32	0.39	NR	NR
Thorium-228	0.48J	0.49J	ND	ND	0.4	0.38	NR	NR
Thorium-232	0.54J	0.58J	0.49J	1.4J	ND	0.83	NR	NR
Uranium-233/234	0.77	0.54	0.86	0.63	0.45	0.45	NR	NR
Uranium-235	ND	0.035R	0.095R	ND	ND	ND	NR	NR
Uranium-238	0.42	0.49	1	0.74	0.45	0.48	NR	NR
Plutonium-238	ND	0.15	ND	0.43	ND	ND	NR	NR
Plutonium-239/240	0.15	12	130J	35	0.027J	ND	NR	NR
Americium-241	0.043J	1.4	12	3.9	0.053	ND	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.5	NR	0.7	0.8	1.1	0.9	12	NR
NO_3, NO_2	32.3	NR	ND	ND	ND	ND	199 (b)	NR
Sulfate	66	NR	19	18	10	19	1,320	NR

a = 95% confidence limit of the 95th percentile of the data distribution.
b = Value reported is for Nitrate only.
J = Estimated value.
R = Value marked as rejected in validation report.
ND = Not detected.
NA = Not analyzed.
NR = Not reported.

Table 3-9 Analytical Results for the 116-F-6 Borehole (page 1 of 2)

Sample Number	B080L9	B080M0	B080M1	B080M2	B080M3	95% UTL (b)	CRQL/CRDL
Depth Interval	0-2 ft	6.5-8.5 ft	9-11 ft	15-17 ft	19-21 ft		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	6,820	5,470	4,800	5,410	4,660	15,600	200
Arsenic	1.4	1.5	1.4	1.6	1.2	8.92	10
Barium	66.3	55.6	46.3	53.3	48.8	171	200
Beryllium	0.32	0.26	0.24	0.26	0.13	1.77	5
Calcium	3,950	3,540	3,390	4,740	5,160	23,920	5,000
Chromium	9.4	30.2	17.1	11.3	8.4	27.9	10
Cobalt	10.3	8.4	6.3	5.9	5.5	19.6	50
Copper	13.4	26.6	12.2	12.3	10.4	28.2	25
Iron	20,800	17,200	12,800	13,000	10,400	39,160	100
Lead	35	7	2.9	2.7	2.5	14.75	3
Magnesium	4,350	4,010	3,480	3,910	3,530	8,760	5,000
Manganese	315	252	216	231	190	612	15
Mercury	0.23	0.19	ND	ND	ND	1.25	0.2
Nickel	10.4	12.1	10.5	8.9	8	25.3	40
Potassium	1,400	754	626	748	607	3,120	5,000
Silver	ND	ND	ND	ND	0.9	2.7	10
Sodium	162	192	191	216	203	1,290	5,000
Vanadium	55.5	46.4	32.3	32.7	25.5	111	50
Zinc	41.2	106	31.3	32.3	24.7	79	20
Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Acetone	14	ND	11	NA	15	NR	10
Benzene	ND	ND	3[J]	NA	2[J]	NR	10
Methylene chloride	2[J]	2[J]	ND	NA	ND	NR	10
Toluene	6[J]	1[J]	12	NA	1[J]	NR	10
Semi Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
bis(2-Ethylhexyl)phthalate	ND	ND	ND	72[J]	ND	NR	330
Di-n-butylphthalate	110[J]	ND	140[J]	ND	ND	NR	330
Pesticides/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
	ND	ND	ND	ND	ND	NR	ND
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross beta	14	350	63	24	22	NR	NR
Potassium-40	8.1	19	13	15	13	NR	NR
Cobalt-60	0.087[J]	33[J]	2.4[J]	ND	ND	NR	NR
Strontium-90	ND	4.4	2.8	4.4	2.1	NR	NR
Cesium-137	0.36	230	20	0.16	ND	NR	NR

Table 3-9 Analytical Results for the 116-F-6 Borehole (page 2 of 2)

Sample Number	B080L9	B080M0	B080M1	B080M2	B080M3	95% UTL (b)	CRQL/CRDL
Depth Interval	0-2 ft	6.5-8.5 ft	9-11 ft	15-17 ft	19-21 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Europium-152	0.5J	190J	18J	1.6J	0.42J	NR	NR
Europium-154	NA	18	2.1	0.14	ND	NR	NR
Radium-226	0.41	1	0.39	0.49	0.39	NR	NR
Thorium-228	0.39	0.47	0.63	0.77	0.49	NR	NR
Thorium-232	0.44	ND	0.58	0.57	0.5	NR	NR
Uranium-233/234	0.43	0.83	0.42	0.45	0.45	NR	NR
Uranium-238	0.51	0.69	0.47	0.42	0.4	NR	NR
Plutonium-238	ND	0.069	ND	ND	ND	NR	NR
Plutonium-239/240	ND	2.5	0.36	0.096	0.088	NR	NR
Americium-241	ND	0.72	0.096	ND	ND	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.5	0.6	0.5	0.5	0.3	12	NR
NO_3, NO_2	ND	2.76	ND	ND	2.51	199 (c)	NR
pH (a)	9.2	9.3	9.4	9.4	ND	NR	NR
Sulfate	10	10	7	9	6	1,320	NR

a = Reported as standard units.
b = 95% confidence limit of the 95th percentile of the data distribution.
c = Value for Nitrate only.
J = Estimated value.
ND = Not detected.
NA = Not analyzed.
NR = Not reported.

Table 3-10 Analytical Results for the 116-F-9C Borehole (page 1 of 2)

Sample Number	B08ON5	B08ON6	B08ON7	B08ON8	B08OP0	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	9-11 ft	14.5-16.5 ft	16.5-18.5 ft	23-25 ft		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	5,220	6,070	3,770	4,250	4,780	15,600	200
Arsenic	2	1	1.5	2.1	0.91	8.92	10
Barium	48.1	64.7	63.3	58.8	58.2	171	200
Beryllium	0.3	0.29	0.22	0.27	0.18	1.77	5
Calcium	3,170	3,550	4,050	4,990	4,670	23,920	5,000
Chromium	7.9	12.2	8.6	10.2	13.8	27.9	10
Cobalt	6.7	8.8	7	9.1	8.6	19.6	50
Copper	13.4	15.7	13.7	18.4	13.9	28.2	25
Iron	13,700	14,800	12,200	17,100	14,600	39,160	100
Lead	3.4	2.8	1.8	2.4	2.2	14.75	3
Magnesium	3,550	3,620	2,750	3,460	3,760	8,760	5,000
Manganese	228	168	158	203	215	612	15
Nickel	8.8	10.4	6.9	9.8	9.2	25.3	40
Potassium	882	1,050	831	726	773	3,120	5,000
Silver	ND	ND	ND	ND	1	2.7	10
Sodium	146	257	203	243	322	1,290	5,000
Vanadium	32.1	42.4	32.4	46	41.3	111	50
Zinc	32	37	29.1	36.5	31.4	79	20
Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
2-Butanone	ND	ND	ND	ND	23	NR	10
Acetone	ND	11	9[J]	11	12	NR	10
Methylene Chloride	ND	4[J]	3[J]	3[J]	3[J]	NR	10
Toluene	10[J]	10[J]	2[J]	2[J]	ND	NR	10
Semi Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Di-n-butylphthalate	ND	ND	ND	ND	74[J]	NR	330
Pesticides/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
alpha-Chlordane	ND	4.7[P]	37[P]	ND	ND	NR	1.7
gamma-Chlordane	ND	4.8[J]	51[J]	ND	ND	NR	1.7
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross beta	11	52	50	43	40	NR	NR
Carbon-14	140	120	ND	ND	ND	NR	NR
Potassium-40	12	12	13	12	8.9[J]	NR	NR
Strontium-90	ND	15	17	19	19	NR	NR
Cesium-137	ND	ND	0.05	ND	ND	NR	NR
Radium-226	0.48	0.62	0.43	0.4	0.36[J]	NR	NR

Table 3-10 Analytical Results for the 116-F-9C Borehole (page 2 of 2)

Sample Number	B0S0N5	B0S0N6	B0S0N7	B0S0N8	B0S0P0	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	9-11 ft	14.5-16.5 ft	16.5-18.5 ft	23-25 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Thorium-228	0.83	0.64	0.62	0.49	0.38J	NR	NR
Thorium-232	0.88	0.66	0.6	0.68	0.39J	NR	NR
Uranium-233/234	0.58	0.38	0.29J	0.29J	ND	NR	NR
Uranium-238	0.53	0.39	0.46	0.36	0.31	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	1	0.9	1.2	1	1	12	NR
NO_3, NO_2	ND	11	4.71	ND	ND	199 (b)	NR
Sulfate	4	256	875	415	95	1,320	NR

a = 95% confidence limit of the 95th percentile of the data distribution.
b = Value reported is for Nitrate only.
J = Estimated value.
NA = Not analyzed.
ND = Not detected.
NR = Not reported.

Table 3-11 Analytical Results for the 116-F-9D Test Pit (page 1 of 2)

Sample Number / Depth Interval	B08G78 / Surface	B08G79 / 9-10 ft	B08G80 / 15 ft	B08G81 / 20 ft	95% UTL (b)	CRQL/ CRDL
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	5,550	6,440	7,760	5,560	15,600	200
Arsenic	1.9	2.9	1.7	1.2	8.92	10
Barium	38	78.3	67.5	59.5	171	200
Beryllium	0.18	0.27	0.31	0.16	1.77	5
Calcium	2,840	5,240	7,190	3,260	23,920	5,000
Chromium	10.1	25.1	12.4	9.2	27.9	10
Cobalt	6.4	10.1	7.9	7	19.6	50
Copper	15.4	32.5	15.7	13.4	28.2	25
Iron	12,900	15,900	16,100	13,300	39,160	100
Lead	3.4	14.6	5.5	3.2	14.75	3
Magnesium	3,920	3,640	4,740	3,950	8,760	5,000
Manganese	233	220	265	210	612	15
Mercury	0.08	0.19	0.11	0.09	1.25	0.2
Nickel	10.7	10.9	11.1	9.4	25.3	40
Potassium	693	1,150	1,400	756	3,120	5,000
Silver	1.2	7.9	1.5	1.4	2.7	10
Sodium	124	161	140	127	1,290	5,000
Vanadium	31.6	38.8	34.1	32.2	111	50
Zinc	27	246	53.4	29.6	79	20
Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
4-Methyl-2-pentanone	ND	13[J]	ND	11[J]	NR	10
Acetone	6[J]	66	6[J]	7[J]	NR	10
Toluene	2[J]	87	18	19	NR	10
Semi Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
bis(2-Ethylhexyl)phthalate	340[J]	ND	59[J]	84[J]	NR	330
Di-n-butylphthalate	76[J]	ND	63[J]	57[J]	NR	330
Pesticides/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
alpha-Chlordane	ND	330	76	6.1	NR	1.7
gamma-Chlordane	ND	200	48	4.1	NR	1.7
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	8.6[J]	ND	5.4[J]	ND	NR	NR
gross beta	19	100	30	29	NR	NR
Potassium-40	15	13	15	13	NR	NR
Cobalt-60	ND	0.074	ND	0.055	NR	NR
Strontium-90	ND	39	10	6.3	NR	NR

Table 3-11 Analytical Results for the 116-F-9D Test Pit (page 2 of 2)

Sample Number	B08G78	B08G79	B08G80	B08G81	95% UTL (b)	CRQL/ CRDL
Depth Interval	Surface	9-10 ft	15 ft	20 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Cesium-137	ND	0.96J	0.17J	0.13J	NR	NR
Europium-152	ND	0.69	ND	0.14	NR	NR
Radium-226	0.63	0.64	0.50	0.38	NR	NR
Thorium-228	1.1J	0.75J	0.65J	0.80J	NR	NR
Thorium-232	0.85J	0.86J	0.76J	0.61J	NR	NR
Uranium-233/234	0.48	0.72	0.55	0.38	NR	NR
Uranium-238	0.45	0.64	0.44	0.37	NR	NR
Plutonium-239/240	ND	0.028J	ND	ND	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.70	0.50	1.2	1.1	12	NR
NO_3, NO_2	2.86	17	14.8	6.74	199 (c)	NR
pH (a)	7.8	7.9	8	8.1	NR	NR
Sulfate	3	480	332	240	1,320	NR

a = Reported as standard units.
b = 95% confidence limit of the 95th percentile of the data distribution.
c = Value reported is for Nitrate only.
J = Estimated value.
NA = Not analyzed.
ND = Not detected.
NR = Not reported.

Table 3-12 Analytical Results for the 116-F-14 Borehole (page 1 of 2)

Sample Number	B080Q4	B080Q5	B080Q6	B080Q7	B080Q8	B080Q9	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	2.5-5 ft	5-7 ft	10.5-13 ft	16.6-18.6 ft	23-24.5 ft		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	6,620	13,000	6,520	5,450	6,170	6,010	15,600	200
Arsenic	2	1.4	0.89	0.82	1.4	0.59	8.92	10
Barium	158	170	65.6	55.7	70.5	79.1	171	200
Beryllium	0.36	0.59	ND	0.26	0.23	ND	1.77	5
Cadmium	ND	ND	1.5	ND	ND	ND	0.66 (b)	5
Calcium	6,710	69,700	6,890	2,830	2,730	3,960	23,920	5,000
Chromium	10.8	16	124	46.4	31.2	35.3	27.9	10
Cobalt	7.9	8.3	8	6	6.1	10.6	19.6	50
Copper	15.6	17.0	29.3	13.6	13.5	15.9	28.2	25
Iron	15,700	17,400	15,000	11,500	12,000	17,400	39,160	100
Lead	5	3.4	4.5	2.5	3.6	2.6	14.75	3
Magnesium	4,110	6,570	4,620	3,960	4,310	4,820	8,760	5,000
Manganese	265	224	240	234	224	260	612	15
Mercury	ND	0.22	ND	0.14	0.11	ND	1.25	0.2
Nickel	10.5	12.9	13.6	8.4	9	20.8	25.3	40
Potassium	1,050	1,200	675	431	619	851	3,120	5,000
Silver	ND	ND	ND	ND	0.79	ND	2.7	10
Sodium	245	703	266	151	158	424	1,290	5,000
Vanadium	40.1	50.5	39.5	25.4	27.3	50.2	111	50
Zinc	37.4	52.9	87.4	26.5	30	39.2	79	20
Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
2-Butanone	ND	ND	ND	ND	ND	2J	NR	10
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	3J	NR	10
Acetone	23	18	17	11	46	11	NR	10
Chloroform	ND	ND	ND	ND	ND	9J	NR	10
Methylene Chloride	3J	3J	4J	4J	4J	ND	NR	10
Toluene	[illegible]	82	[illegible]	2J	2J	16	NR	10
Semi Volatile Organics	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
bis(2-Ethylhexyl)phthalate	87J	50J	78J	200J	100J	37J	NR	330
Di-n-butylphthalate	340J	300J	[illegible]	150J	150J	130J	NR	330
Diethylphthalate	ND	ND	ND	ND	ND	2,600	NR	330
Pesticides/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
	ND	ND	ND	ND	ND	ND	NR	ND
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	ND	14	ND	ND	[illegible]	ND	NR	NR

Table 3-12 Analytical Results for the 116-F-14 Borehole (page 2 of 2)

Sample Number	B080Q4	B080Q5	B080Q6	B080Q7	B080Q8	B080Q9	95% UTL (a)	CRQL/ CRDL
Depth Interval	0-2 ft	2.5-5 ft	5-7 ft	10.5-13 ft	16.6-18.6 ft	23-24.5 ft		
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross beta	12	440	290	21	13	11	NR	NR
Carbon-14	ND	28J	7.3J	ND	ND	ND	NR	NR
Potassium-40	11	ND	ND	12	9.4	15	NR	NR
Cobalt-60	ND	43J	53J	ND	ND	ND	NR	NR
Strontium-90	ND	16J	2.6J	ND	ND	ND	NR	NR
Cesium-137	ND	6.4R	12	5.8R	2.1R	1.5J	NR	NR
Europium-152	1.2	940	450	ND	ND	ND	NR	NR
Europium-154	0.97J	130J	54J	ND	ND	ND	NR	NR
Europium-155	NA	6.6	2.7	NA	NA	ND	NR	NR
Radium-226	0.5	ND	ND	0.51	0.41	0.51	NR	NR
Thorium-228	0.6	ND	ND	0.58	0.47	0.62J	NR	NR
Thorium-232	0.6	ND	ND	0.74	0.54	0.75J	NR	NR
Uranium-233/234	0.41	0.57	0.94	0.55	0.5	0.38	NR	NR
Uranium-238	0.33	0.66	0.76	0.53	0.38	0.38	NR	NR
Plutonium-238	ND	0.13	0.12	ND	ND	0.24J	NR	NR
Plutonium-239/240	ND	5.1	3.7	0.021J	ND	0.035J	NR	NR
Americium-241	ND	0.98	0.81	ND	ND	ND	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.6	0.6	0.4	0.4	0.8	0.8	12	NR
NO_3, NO_2	3.17	2.51	ND	ND	ND	ND	199 (c)	NR
Sulfate	12	14	57	7	8	8	1,320	NR

a = 95% confidence limit of the 95th percentile of the data distribution
b = Value reported is limit of detection.
c = Value for Nitrate only.
J = Estimated value.
R = Value marked as rejected in validation report.
ND = Not detected.
NA = Not analyzed.
NR = Not reported.

Table 3-13 Analogous Site Comparison for 116-F-14 (page 1 of 2)

Maximum Concentration	116-F-14	116-C-5	116-D-7	116-DR-9	116-H-7	95% UTL (c)	CRQL/CRDL
INORGANICS (a)	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Arsenic	-	-	-	12.4[*]	47	8.92	10
Cadmium	1.5	-	-	1.2	-	0.66 (d)	5
Chromium	124	609[J]	51.6	73.4[J]	28.3[J]	27.9	10
Copper	29.3	46.8	-	-	-	28.2	25
Lead	-	564[J]	-	-	540	14.75	3
Mercury	-	4.3	-	-	-	1.25	0.2
Nickel	-	-	-	37[J]	-	25.3	40
Zinc	87.4	309	-	-	83.1[J]	79	20
VOLATILE ORGANICS	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
2-Butanone	2[J]	-	-	-	-	NR	10
4-Methyl-2-pentanone	3[J]		-	-	-	NR	10
Acetone	46	-		55[J]	-	NR	10
Chloroform	9[J]	-	-	-	-	NR	10
Methylene Chloride	4[J]	-	-	16[J]	-	NR	10
Toluene	82			11	49	NR	10
Trichloroethene	-	-	-	6	-	NR	10
SEMI VOLATILE ORGANICS	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
2-Nitrophenol	-			350[J]	-	NR	330
Anthracene	-	-		150[J]	-	NR	330
Benzo(a)anthracene	-	77[J]	-	130[J]	-	NR	330
Benzo(a)pyrene	-	-	-	110[J]	-	NR	330
Benzo(b)fluoranthene	-	100[J]	-	120[J]	-	NR	330
Benzo(ghi)perylene		-		85[J]	-	NR	330
Benzo(k)fluoranthene		100[J]		95[J]	-	NR	330
Benzoic acid	-	-	-	74[J]	-	NR	-
bis(2-ethylhexyl)phthalate	200[J]			5,200	-	NR	330
Butylbenzylphthalate	-			2,200	-	NR	330
Chrysene		100[J]		140[J]	-	NR	330
Diethylphthalate	2,600			34[J]	-	NR	330
Di-n-butylphthalate	340[J]		89[J]	2,900		NR	330
Fluoranthene	-	67[J]	-	240[J]	-	NR	330
Indeno(1,2,3-cd)pyrene				76[J]	-	NR	330
Pentachlorophenol		320[J]		56[J]		NR	1,700
Phenol			350[J]			NR	330
Pyrene	-			350	-	NR	330
PESTICIDES/PCB	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
Aroclor-1260	-			130[J]	-	NR	330

Table 3-13 Analogous Site Comparison for 116-F-14 (page 2 of 2)

MAXIMUM CONCENTRATION	116-F-14	116-C-5	116-D-7	116-DR-9	116-H-7	95% UTL (c)	CRQL/CRDL
RADIONUCLIDES (b)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Carbon-14	28[J]	640[J]	-	25.06	-	NR	-
Potassium-40	12	-	15.8[J]	14.7	-	NR	-
Cobalt-60	53[J]	310	-	-	36	NR	
Strontium-90	16[J]	770	1.9[J]	3.8	3.2	NR	
Technetium-99	-	-	-	1.5[R]	-	NR	-
Cesium-137	12	800	9.55[J]	1.98	35	NR	
Europium-152	940	1,400	-	-	260	NR	
Europium-154	130[J]	410	-		37	NR	-
Europium-155	6.6	41				NR	
Radium-226				1.25[J]	-	NR	-
Thorium-228	-	-	-	1.02	-	NR	-
Uranium-233/234		1.4[R]		-	-	NR	-
Uranium-238		1.3[R]	-	-	-	NR	-
Plutonium-238		9.4[R]		-	-	NR	-
Plutonium-239/240	5.1	190[R]	-	-	1.3	NR	-
Americium-241	-	34	-	-	-	NR	-

a = Inorganic values were screened against Hanford Site background 95% UTL, Region X excluded elements
b = Only radionuclides greater than 1 pCi/g were reported.
c = 95% confidence limit of the 95th percentile of the data distribution.
d = Value reported is limit of detection.
J = Value is estimated, concentration less than contract required detection limit.
R = Value marked as rejected in validation report.
\- = Not detected.
NR = Not reported.
Analogous site data taken from associate LFI reports. (DOE-RL 1993b), (DOE-RL 1993c), (DOE-RL 1993d).

Table 3-14 Analytical Results for the 108-F French Drain (page 1 of 2)

Sample Number / Depth Interval	B080R4 / 0-1 ft	B080R6 / 3.5-4.5 ft	95% UTL (a)	CRQL/ CRDL
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	4,280	6,110	15,600	200
Antimony	3.7'	3.9'	15.7 (b)	60
Arsenic	6.2	4	8.92	10
Barium	64.7	37.8	171	200
Beryllium	0.12	0.18	1.77	5
Calcium	1,550	2,160	23,920	5,000
Chromium	164	99.3	27.9	10
Cobalt	4.7	7.1	19.6	50
Copper	73.8	39.1	28.2	25
Iron	17,700'	20,500'	39,160	100
Lead	73.2	34.6	14.75	3
Magnesium	2,210	3,740	8,760	5,000
Manganese	116	195	612	15
Mercury	0.48	0.09	1.25	0.2
Nickel	17.3	21.3	25.3	40
Potassium	998	1,160	3,120	5,000
Selenium	0.78	ND	5 (b)	5
Sodium	130	171	1,290	5,000
Vanadium	27.2	44.2	111	50
Zinc	79.7	129	79	20
Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg
Toluene	36	480	NR	10
Semi Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg
Benzo(a)anthracene	ND	62'	NR	330
bis(2-Ethylhexyl)phthalate	4,100'	580'	NR	330
Fluoranthene	ND	45'	NR	330
Pyrene	ND	43	NR	330
Pesticides/PCB	μg/kg	μg/kg	μg/kg	μg/kg
Aroclor-1254	1,600"	240'	NR	33
Aroclor-1260	720"	150'	NR	33
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	250	56	NR	NR
gross beta	ND	13	NR	NR
Potassium-40	9.5	13	NR	NR
Cesium-137	1.6'	0.74'	NR	NR

Table 3-14 Analytical Results for the 108-F French Drain (page 2 of 2)

Sample Number / Depth Interval	8080R4 / 0-1 ft	8080R5 / 3.5-4.5 ft	95% UTL (a)	CRQL/ CRDL
Radionuclides (cont'd)	pCi/g	pCi/g	pCi/g	pCi/g
Europium-152	0.12	ND	NR	NR
Radium-226	0.41	0.42	NR	NR
Thorium-228	0.55 J	0.81 J	NR	NR
Thorium-232	0.50 J	0.75 J	NR	NR
Uranium-233/234	0.46	0.45	NR	NR
Uranium-238	0.47	0.42	NR	NR
Plutonium-238	220 J	66 J	NR	NR
Plutonium-239/240	34	11	NR	NR
Americium-241	3.3	1.2	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	0.60	0.40	12	NR
NO_3, NO_2	323	85	199 (c)	NR
Sulfate	150	47	1,320	NR

a = 95% confidence limit of the 95th percentile of the data distribution.
b = Value reported is limit of detection.
c = Value for Nitrate only.
J = Estimated value.
R = Value marked as rejected in validation report.
NA = Not analyzed.
ND = Not detected.
NR = Not reported.

Table 3-15 Analogous Site Comparison for 116-F-8

MAXIMUM CONCENTRATION	116-DR-5	116-D-5	95% UTL (b)	CRQL/CRDL
VOLATILE ORGANICS	µg/kg	µg/kg	µg/kg	µg/kg
Trichloroethene	-	5	NR	10
SEMI VOLATILE ORGANICS	µg/kg	µg/kg	µg/kg	µg/kg
bis(2-Ethylhexyl)phthalate	5,500	-	NR	330
Butylbenzylphthalate	2,100	-	NR	330
Di-n-butylphthalate	1,900J	-	NR	330
PESTICIDES/PCB	µg/kg	µg/kg	µg/kg	µg/kg
Dieldrin	2.1J	-	NR	3.3
RADIONUCLIDES (a)	pCi/g	pCi/g	pCi/g	pCi/g
Potassium-40	13.5J	12J	NR	-

a = Only radionuclides greater than 1 pCi/g were reported.
b = 95% confidence limit of the 95th percentile of the data distribution.
J = Value is estimated, concentration less than contract required detection limit.
\- = Not detected.
NR = Not reported.
Analogous site data taken from associate LFI reports, (DOE-RL 1993b), (DOE-RL 1993c), (DOE-RL 1993d).

Table 3-16 Analytical Results for the 132-F-1 Test Pit (page 1 of 3)

Sample Number	B07201	B07202	B07203	B07204	95% UTL (a)	CRQL/ CRDL
Depth Interval	Sample	Duplicate	Split	Blank		
Inorganics	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	5,020	5,070	2,820	NR	15,600	200
Arsenic	2.7	ND	0.77	NR	8.92	10
Barium	35.1	39.5	23.6	NR	171	200
Beryllium	ND	ND	0.35	NR	1.77	5
Calcium	5,520	5,780	4,490	NR	23,920	5,000
Chromium	8.2	8.7	5.5	NR	27.9	10
Cobalt	6	6.2	5.4	NR	19.6	50
Copper	12.8	12.3	10.4	NR	28.2	25
Iron	12,200	12,200	7,450	NR	39,160	100
Lead	3.8	4.1	2.5	NR	14.75	3
Magnesium	3,680	3,720	2,180	NR	8,760	5,000
Manganese	221	240	154	NR	612	15
Nickel	9	9.2	6	NR	25.3	40
Potassium	618	676	494	NR	3,120	5,000
Selenium	2.1	1.8	ND	NR	5 (b)	5
Sodium	172	136	102	NR	1,290	5,000
Vanadium	29.4	29.6	14.4	NR	111	50
Zinc	30.3	32.7	19.9	NR	79	20
Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
2-Butanone	4	ND	ND	ND	NR	10
4-Methyl-2-pentanone	3	ND	ND	ND	NR	10
Acetone	ND	ND	34	ND	NR	10
Methylene Chloride	ND	5	ND	4	NR	10
Semi Volatile Organics	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
Benzo(a)anthracene	44	79	ND	NR	NR	330
Benzo(a)pyrene	ND	71	ND	NR	NR	330
Benzo(b)fluoranthene	40	38	ND	NR	NR	330
Benzo(k)fluoranthene	ND	30	ND	NR	NR	330
bis(2-Ethylhexyl)phthalate	56	ND	380	NR	NR	330
Chrysene	48	35	ND	NR	NR	330
Fluoranthene	51	[illegible]	ND	NR	NR	330
Phenanthrene	53	[illegible]	ND	NR	NR	330
Pyrene	58	[illegible]	ND	NR	NR	330
Pesticides/PCB	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg	μg/kg
gamma-Chlordane	2.5	[illegible]	ND	NR	NR	1.7

Table 3-16 Analytical Results for the 132-F-1 Test Pit (page 2 of 3)

Sample Number	B07201	B07202	B07203	B07204	95% UTL (a)	CRQL/ CRDL
Depth Interval	Sample	Duplicate	Split	Blank		
Radionuclides	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
gross alpha	1.8[a]	3.8[a]	4.2[a]	NR	NR	NR
gross beta	12[a]	19	35[a]	NR	NR	NR
Beryllium-7	ND	ND	0.3[a]	NR	NR	NR
Carbon-14	ND	ND	-0.27[a]	NR	NR	NR
Potassium-40	9.4	13	13[a]	NR	NR	NR
Manganese-54	ND	ND	0.02[a]	NR	NR	NR
Cobalt-58	ND	ND	0.03[a]	NR	NR	NR
Iron-59	ND	ND	0.09[a]	NR	NR	NR
Cobalt-60	ND	ND	0.03[a]	NR	NR	NR
Zinc-65	ND	ND	0.07[a]	NR	NR	NR
Strontium-90	ND	ND	0.024[a]	NR	NR	NR
Zirconium-95	ND	ND	0.04[a]	NR	NR	NR
Ruthenium-103	ND	ND	0.04[a]	NR	NR	NR
Ruthenium-106	ND	ND	0.2[a]	NR	NR	NR
Iridium-131	ND	ND	0.6[a]	NR	NR	NR
Cesium-134	ND	ND	0.03[a]	NR	NR	NR
Cesium-137	ND	ND	0.02[a]	NR	NR	NR
Barium-140	ND	ND	0.2[a]	NR	NR	NR
Cerium-141	ND	ND	0.07[a]	NR	NR	NR
Cerium-144	ND	ND	0.2[a]	NR	NR	NR
Europium-152	ND	ND	[illegible]	NR	NR	NR
Europium-154	ND	ND	0.09[a]	NR	NR	NR
Europium-155	ND	ND	0.05[a]	NR	NR	NR
Radium-226	0.36	0.44	0.50[a]	NR	NR	NR
Thorium-228	0.61	0.57	0.498[a]	NR	NR	NR
Thorium-232	0.57	0.62	ND	NR	NR	NR
Thorium-234	ND	ND	0.40[a]	NR	NR	NR
Uranium-233/234	0.73[a]	0.65[a]	ND	NR	NR	NR
Uranium-235	0.13[a]	0.14[a]	0.0018[a]	NR	NR	NR
Uranium-238	0.21[a]	0.18[a]	0.092[a]	NR	NR	NR
Plutonium-238	0.005[a]	ND	ND	NR	NR	NR
Plutonium-239/240	0.005[a]	ND	[illegible]	NR	NR	NR
Anions	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Fluoride	ND	4	2.4	NR	12	NR
NO_3, NO_2	-	NR	NR	NR	199 (c)	NR

Table 3-16 Analytical Results for the 132-F-1 Test Pit (page 3 of 3)

Sample Number	B07201	B07202	B07203	B07204	95% UTL (a)	CRQL/ CRDL
Depth Interval	Sample	Duplicate	Split	Blank		
Anions (cont'd)	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Sulfate	0.51	34	33	NR	580	NR

a = 95% confidence limit of the 95th percentile of the data distribution.
b = Value reported is limit of detection.
c = Value reported is for Nitrate only.
J = Estimated value.
R = Value marked as rejected in validation report.
NA = Not analyzed.
ND = Not detected.
NR = Not reported.

Table 3-17 Potential Federal Chemical-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit (page 1 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks
Atomic Energy Act of 1954, as amended	42 U.S.C. 2011 et seq.		Authorizes DOE to set standards and restrictions governing facilities used for research, development, and utilization of atomic energy.	
Radiation Protection Standards	40 CFR Part 191		Establishes standards for management and disposal of high-level and transuranic waste and spent nuclear fuel.	
Standards for Management and Storage	40 CFR §191.03	A	Requires that management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities for the disposal of such fuel or waste that are operated by the DOE and that are not regulated by the Commission or Agreement States shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirems to the whole body and 75 millirems to any critical organ.	Applicable to wastes disposed of after November 18, 1985.
Nuclear Regulatory Commission Standards for Protection Against Radiation	10 CFR Part 20			
Radiation Dose Standards	10 CFR §§20.101-20.105	R&A	Sets specific radiation doses, levels, and concentrations for restricted and unrestricted areas.	May be relevant and appropriate, as radioactive materials in the 100 Area can contribute radiation doses, levels, and concentrations which could exceed the limits; however, Hanford is not an NRC-licensed facility.

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Table 3-17 Potential Federal Chemical-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit (page 2 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks
Safe Drinking Water Act	42 U.S.C. 300f et seq.		Creates a comprehensive national framework to ensure the quality and safety of drinking water.	
National Primary Drinking Water Regulations	40 CFR Part 141	R&A	Establishes maximum contaminant levels (MCL) and maximum contaminant level goals (MCLG) for organic, inorganic, and radioactive constituents. The MCL for combined radium-226 and radium-228 is 5 pCi/L. The MCL for gross alpha particle activity (including radium-226 but excluding radon and uranium) is 15 pCi/L. The average annual concentration of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to total body or any internal organ in excess of 4 millirem/year.	Applicable to public water systems. Potential chemicals and radionuclides of concern may migrate to the drinking water supply as a result of remedial activities. Although federal MCLGs are not enforceable standards, they are potential ARARs under the Washington State Model Toxics Control Act when more stringent than other standards. See state ARARs.
National Secondary Drinking Water Regulations	40 CFR Part 143	R&A	Controls contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water.	Although federal secondary drinking water standards are not enforceable, they are potential ARARs under the Washington State Model Toxics Control Act when more stringent than other standards. See state ARARs.
Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA)	42 U.S.C. 6901 et seq.		Establishes the basic framework for federal regulation of solid and hazardous waste.	
Groundwater Protection Standards	40 CFR §264.92 [WAC 173-303-645][a]	A	A facility shall not contaminate the uppermost aquifer underlying the waste management area beyond the point of compliance, which is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated area. The concentration of certain chemicals shall not exceed background levels, certain specified maximum concentrations, or alternate concentration limits, whichever is higher.	Groundwater concentration limits in this section do not exceed 40 CFR 141, except for chromium which has a limit of 50 $\mu g/L$.

[a]These are State of Washington regulatory citations which are equivalent to Title 40 Code of Federal Regulations, Parts 264 and 268 as stated in Washington Administrative Code 173-303.

Table 3-17 Potential Federal Chemical-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit (page 3 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks
Uranium Mill Tailings Radiation Control Act of 1978	Public Law 95-604, as amended			
Standards for Uranium and Thorium Mill Tailings	40 CFR 192		Establishes standards for control, cleanup, and management of radioactive materials from inactive uranium processing sites.	
Land Cleanup Standards	40 CFR §§192.10 - 192.12	R&A	Requires remedial actions to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site, the concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than 5 pCi/g, averaged over the first 15 cm of soil below the surface, and 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface. In any habitable building, a reasonable effort shall be made during remediation to achieve an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 Working Level (WL). In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL and the level of gamma radiation shall not exceed the background level by more than 20 microroentegens per hour.	May be relevant and appropriate, as any radium-226 encountered during remediation did not result from uranium processing.
Implementation	40 CFR §§192.20 192.23	R&A	Requires that when radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials, remedial action shall reduce other residual radioactivity to levels as low as reasonably achievable (ALARA).	May be relevant and appropriate, as any radium-226 encountered during remediation did not result from uranium processing.

*NOTE: A = Applicable, R&A = Relevant and Appropriate

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Table 3-18 Potential State Chemical-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit (page 1 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks
Model Toxics Control Act (MTCA)	70.105D RCW		**Requires remedial actions to attain a degree of cleanup protective of human health and the environment.**	
Cleanup Regulations	WAC 173-340		Establishes cleanup levels and prescribes methods to calculate cleanup levels for soils, groundwater, surface water, and air.	
Groundwater Cleanup Standards	WAC 173-340-720	A	Requires that where the groundwater is a potential source of drinking water, cleanup levels under Method B must be at least as stringent as concentrations established under applicable state and federal laws, including the following: (A) Maximum contaminant levels established under the Safe Drinking Water Act and published in 40 CFR 141, as amended; (B) Maximum contaminant level goals for noncarcinogens established under the Safe Drinking Water Act and published in 40 CFR 141, as amended; (C) Secondary maximum contaminant levels established under the Safe Drinking Water Act and published in 40 CFR 143, as amended; and (D) Maximum contaminant levels established by the state board of health and published in Chapter 248-54 WAC, as amended.	Federal maximum contaminant level goals for drinking water (40 CFR Part 141) and federal secondary drinking water regulation standards (40 CFR Part 143) are potential ARARs under MTCA when they are more stringent than other standards. Method B cleanup levels are levels applicable to remediation at Hanford unless a demonstration can be made that method C (alternate cleanup levels) is valid.

Table 3-18 Potential State Chemical-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit (page 2 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks
Soil Cleanup Standards	WAC 173-340-740	A	MTCA Method B concentration limits in milligrams per kilogram for potential contaminants in soils, sediments, and sludges are: Barium 5,600 Cadmium 40 Chromium (III) 80,000 Chromium (VI) 400 Copper 3,200 Manganese 400 Mercury 24 Silver 400 Zinc 24,000 Acetone 8,000 Benzene 34.5 Carbon disulfide 8,000 Methyl ethyl ketone 48,000 Methyl isobutyl ketone 4,000 Methylene chloride 133 Toluene 16,000 Anthracene 24,000 Benzo(a)anthracene 0.137 Benzo(b)fluoranthene 0.137 Benzo(k)fluoranthene 0.137 Benzoic acid 320,000 Benzyl alcohol 24,000 Bis(2-ethylhexyl)phthalate 71.4 Chrysene 0.137 Di-n-butylphthalate 8,000 Diethyl phthalate 64,000 Fluoranthene 3,200 N-nitrosodiphenylamine 204 Pentachlorophenol 8.33 Pyrene 2400	

Table 3-18 Potential State Chemical-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit (page 3 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks
Washington State Department of Health	RCW 43.70			
Radiation Protection -- Air Emissions	WAC 246-247		Establishes procedures for monitoring, control, and reporting of airborne radionuclide emissions.	
New and Modified Sources	WAC 246-247-070	A	Requires the use of best available radionuclide control technology (BARCT).	
Radiation Protection Standards	WAC 246-221		Establishes standards for protection against radiation hazards.	
Radiation dose to individuals in restricted areas	WAC 246-221-010	A	Specifies dose limits to individuals in restricted areas for hands and wrists, ankles and feet of 18.75 rem/quarter and for skin of 7.5 rem/quarter.	

*NOTE: A = Applicable, R&A = Relevant and Appropriate

Table 3-19 Potential Chemical-Specific To-Be-Considered Guidance for the 100-FR-1 Operable Unit (page 1 of 2)

Description	Citation	Requirements	Remarks
Model Toxics Control Act	70.105D RCW		
Cleanup Regulations	WAC 173-340	The State Department of Ecology is currently adapting the calculations in MTCA to be applicable to radioactive contaminants. These cleanup standards may become available prior to or during remediation.	
Solid Waste Disposal Act, as amended by RCRA	42 U.S.C. 6901 et seq.		
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR §257.3-4	A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary.	The courts or the state may establish alternate boundaries.
Corrective Action for Solid Waste Management Units	40 CFR 264 Subpart S, proposed	Establishes requirements for investigation and corrective action for releases of hazardous waste from solid waste management units.	
U.S. Department of Energy Orders			
Radiation Protection of the Public and the Environment	DOE 5400.5	Establishes radiation protection standards for the public and environment.	
Radiation Dose Limit (All Pathways)	DOE 5400.5, Chapter II, Section 1a	The exposure of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem from all exposure pathways, except under specified circumstances.	Pertinent if remedial activities are "routine DOE activities."
Radiation Dose Limit (Drinking Water Pathway)	DOE 5400.5, Chapter II, Section 1d	Provides a level of protection for persons consuming water from a public drinking water supply operated by DOE so that persons consuming water from the supply shall not receive an effective dose equivalent greater than 4 mrem per year. Combined radium-226 and radium-228 shall not exceed 5 x 10^{-9} µCi/mL and gross alpha activity (including radium-226 but excluding radon and uranium) shall not exceed 1.5 x 10^{-8} µCi/mL.	Pertinent if radionuclides may be released during remediation.

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Table 3-19 Potential Chemical-Specific To-Be-Considered Guidance for the 100-FR-1 Operable Unit (page 2 of 2)

Description	Citation	Requirements	Remarks
Residual Radionuclides in Soil	DOE 5400.5 Chapter IV. Section 4a	Generic guidelines for radium-226 and radium-228 are: • 5 pCi/g averaged over the first 15 cm of soil below the surface; and • 15 pCi/g averaged over 15-cm-thick layers of soil more than 15 cm below the surface. Guidelines for residual concentrations of other radionuclides must be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these deviations are given in "A Manual for Implementing Residual Radioactive Material Guidelines" (DOE/CH-8901). Procedures for determination of "hot spots," "hot-spot cleanup limits," and residual concentration guidelines for mixtures are in DOE/CH-8901. Residual radioactive materials above the guidelines must be controlled to the required levels in 5400.5, Chapter II and Chapter IV.	Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 m^2.

Table 3-20 Potential Federal Location-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit

Description	Citation	A/ R&A*	Requirements	Remarks
Archaeological and Historical Preservation Act of 1974	16 U.S.C. 469	A	Requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts.	Applicable when remedial action threatens significant scientific, prehistorical, historical, or archaeological data.
Endangered Species Act of 1973	16 U.S.C. 1531 et seq.		Prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival.	
Fish and Wildlife Services List of Endangered and Threatened Wildlife and Plants	50 CFR Parts 17, 222, 225, 226, 227, 402, 424	A	Requires identification of activities that may affect listed species. Actions must not threaten the continued existence of a listed species or destroy critical habitat.	Requires consultation with the Fish and Wildlife Service to determine if threatened or endangered species could be impacted by activity.
Historic Sites, Buildings, and Antiquities Act	16 U.S.C. 461	A	Establishes requirements for preservation of historic sites, buildings, or objects of national significance. Undesirable impacts to such resources must be mitigated.	
Wild and Scenic Rivers Act	16 U.S.C 1271	A	Prohibits federal agencies from recommending authorization of any water resource project that would have a direct and adverse effect on the values for which a river was designated as a wild and scenic river or included as a study area.	The Hanford Reach of the Columbia River is under study for inclusion as a wild and scenic river.

*NOTE: A = Applicable, R&A = Relevant and Appropriate

Table 3-21 Potential State Location-Specific Applicable or Relevant and Appropriate Requirements for the 100-FR-1 Operable Unit

Description	Citation	A/ R&A*	Requirements	Remarks
Habitat Buffer Zone for Bald Eagle Rules	RCW 77.12.655			
Bald Eagle Protection Rules	WAC 232-12-292	A	Prescribes action to protect bald eagle habitat, such as nesting or roost sites, through the development of a site management plan.	Applicable if the areas of remedial activities includes bald eagle habitat.
Regulating the Taking or Possessing of Game	RCW 77.12.040			
Endangered, Threatened, or Sensitive Wildlife Species Classification	WAC 232-12-297	A	Prescribes action to protect wildlife classified as endangered, threatened, or sensitive, through development of a site management plan.	Applicable if wildlife classified as endangered, threatened, or sensitive are present in areas impacted by remedial activities.

*NOTE A = Applicable, R&A = Relevant and Appropriate

Table 3-22 Potential Location-Specific To-Be-Considered Guidance for the 100-FR-1 Operable Unit

Description	Citation	Requirements	Remarks
Floodplains/Wetlands Environmental Review	10 CFR Part 1022	Requires federal agencies to avoid, to the extent possible, adverse effects associated with the development of a floodplain or the destruction or loss of wetlands.	Pertinent if remedial activities take place in a floodplain or wetlands.
Protection and Enhancement of the Cultural Environment	Executive Order 11593	Provides direction to federal agencies to preserve, restore, and maintain cultural resources.	Pertains to sites, structures, and objects of historical, archeological, or architectural significance.
Hanford Reach Study Act	PL 100-605	Provides for a comprehensive river conservation study. Prohibits the construction of any dam, channel, or navigation project by a federal agency for 8 years after enactment. New federal and non-federal projects and activities are required, to the extent practicable, to minimize direct and adverse effects on the values for which the river is under study and to utilize existing structures.	This law was enacted November 4, 1988.

4.0 SUMMARY AND CONCLUSIONS OF THE QUALITATIVE RISK ASSESSMENT

This section provides a summary of the methods and results of the QRA that was performed for the high-priority waste sites in the 100-FR-1 Operable Unit. Complete results and methodology used for the QRA are provided in the QRA of the 100-FR-1 Source Operable Unit (WHC 1993).

Data used for this 100-FR-1 QRA are from historical information and recent LFI sampling. The data are evaluated using the *Hanford Site Risk Assessment Methodology* (DOE-RL 1994a) as guidance. The maximum detected representative constituent concentrations in the top 15 ft of the soil are compared to Hanford Site Soil Background (DOE-RL 1993a). Constituent concentrations greater than background (inorganic only) are compared to risk-based benchmark concentrations. For both the human health and ecological evaluations, maximum constituent concentrations exceeding either of these criteria are retained for further evaluation.

The 100-FR-1 Operable Unit QRA presents a qualitative evaluation of human health and ecologic risks associated with the high priority and nonprioritized waste sites included in the 100-FR-1 Operable Unit. The human health QRA evaluates two exposure scenarios (i.e., frequent- and occasional-use) over four exposure pathways (i.e., soil ingestion, fugitive dust inhalation, inhalation of volatile organics, and external radiation exposure). The ecologic QRA estimates risks to a selected ecological receptor, the Great Basin pocket mouse. The use of these scenarios and pathways was agreed to by the 100 Area Tri-Party unit managers (December 21, 1992 and February 8, 1993). The reductions in human health risks from delaying the onset of human exposures to the year 2018 (i.e., decreasing radionuclide COPC soil concentrations through radioactive decay) and from external radiation shielding effects provided by clean-fill soil cover are also estimated. This QRA is not intended to replace or be a substitute for a baseline risk assessment.

This QRA includes conservative assumptions which simplify the risk characterization process, resulting in qualified estimates of risks and hazards to human health. The use of the numerical risk and hazard estimates in the 100-FR-1 Operable Unit QRA should be limited to comparisons with QRA for other operable units evaluated using the same methodology (DOE-RL 1994a).

4.1 HUMAN HEALTH QUALITATIVE RISK ASSESSMENT

The 100-FR-1 Operable Unit human health QRA provides estimates of risks that occur under frequent-use or occasional-use scenarios based on the best available knowledge of current waste site conditions. Because neither of these exposure scenarios currently occur, risks that might occur for humans under frequent- and occasional-use were included to provide an upper and lower bound estimate of risk to a reasonable maximum exposure individual.

4.1.1 Results of the Human Health QRA

Table 4-1 and Figure 4-1 summarize the results of the 100-FR-1 Operable Unit human health risk characterization of waste sites. Nine of the fourteen waste sites for which there are soil analysis data are considered to have "high" human health risks in the frequent-use scenario. As such, these sites should continue on the IRM path.

The external radiation exposure pathway is shown to be the primary risk-contributing pathway at all of the evaluated waste sites. No separate figure is produced for the external radiation pathway as it so overwhelms the other two pathways. The total human health risk is the external exposure risk. Consequently, radionuclide COPC that are external radiation exposure hazards (cobalt-60, cesium-137, europium-152, and europium-154) are considered the primary risk-contributing COPC. Chemicals (arsenic, chromium, PCB) and radionuclide COPC that represent internal radiation hazards (tritium, carbon-14, strontium-90, etc.) represent insignificant human health risks in comparison to the primary risk-contributing COPC. Figure 4-1 also demonstrates that the inhalation, and ingestion exposure pathways represent much lower human health risks than does the external radiation pathway at the 100-FR-1 Operable Unit waste sites.

The potential decreases in human health risks from delaying the onset of human frequent-use scenario exposures to the year 2018 are shown in Figure 4-2. A reduction of one qualitative risk category (i.e., "high" risk reduced to the "medium" risk category) is anticipated at five of the fourteen evaluated waste sites under the frequent-use scenario. This reduction in risk can be primarily attributed to the radioactive decay of cobalt-60, cesium-137, europium-152, and europium-154.

4.1.2 Summary of Key Uncertainties in the Human Health Risk Assessment

The human health risks presented in this QRA are conditional estimates that reflect multiple assumptions and related uncertainties. This section discusses the sources of uncertainty that were considered to have the greatest influence on the conclusions of the 100-FR-1 Operable Unit QRA.

The use of maximum soil concentrations of all COPC from the surface to a depth of 4.6 m (15 ft) as the exposure point concentration ignores the spatial distributions of surface and subterranean COPC concentrations that exist at all waste sites. Because the maximum concentrations are assumed to be ubiquitous and readily accessible to potential human receptors, this source of uncertainty results in over estimation of the exposure intakes, and corresponding health risks, from all COPC detected at each waste site.

Exposure estimates for hypothetical human receptors include an extrapolation of external radiation field properties and air COPC particulate concentrations from soil COPC concentrations. Direct measurements, such as those provided by external radiation dosimeters, are expected to significantly reduce this source of uncertainty in the 100-FR-1 Operable Unit QRA.

The assumption of a homogenous distribution of the maximum soil concentration of each radionuclide COPC ("infinite source" geometry) is used to evaluate individual external radiation exposure risks. Uncertainty is introduced into the QRA because this assumption ignores the differences in radiation intensity provided for any other distribution of radionuclide COPC in soil, and results in an over estimation of the external radiation exposure risks. Because the external radiation exposure pathway was found to be the primary risk-contributing pathway at all evaluated waste sites, this source of uncertainty is expected to significantly impact the 100-FR-1 Operable Unit QRA.

Table 4-2 summarizes the qualitative risk evaluation of waste sites that have no soil analysis data. Historical information and risk estimates from analogous sites were used to estimate the qualitative risk category for such sites. The accuracy of the estimated qualitative risk category is highly dependent on the appropriateness of the selected analogous waste site. This major source of uncertainty can be reduced as site-specific data become available for these waste sites.

4.2 ECOLOGICAL QUALITATIVE RISK ASSESSMENT

4.2.1 Results of the Ecological Evaluation

A qualitative ecological evaluation was completed for radiological constituents for the 100-FR-1 Operable Unit. The findings are:

- Historical data indicate that 116-F-4 Pluto Crib exceeds the EHQ (Table 4-3) at the surface 0-1.8 m (0-6 ft) soil profile as well as the total the 0-4.6 m (0-15 ft) depth, although it is recognized that the Pluto Crib was excavated in 1993.

- Eight sites (Table 4-4) exceed the wildlife NOEL (EHQ > 1) for one or more nonradiological contaminants. These sites include: the 108 French Drain, the 116-F-1 Lewis Canal, the 116-F-2 Basin Overflow, the 116-F-3 Fuel Storage Basin Trench, the 116-F-4 Pluto Crib (historical data), the 116-F-6 Liquid Waste Disposal Trench, the 116-F-9 Animal Waste Leach Trench, and the 116-F-14 Retention Basin.

The estimation of significant EHQ for radionuclides within 1.8 m (6 ft) of the soil surface, indicates that radionuclides at 116-F-4 Pluto Crib are available for uptake by plants and can be biologically transported to the pocket mouse. Radionuclides at the 116-F-9 Animal Leach Trench, however, did not exceed the EHQ of 1 rad/day (0.8 rad/day) within the 4.6 m (15 ft) of soil. The top 1.8 m (6 ft) of soil was three orders of magnitude less than the total 4.6 m (15 ft) soil profile. This result indicates that there is less of a hazard for biotransport of contaminants to the pocket mouse. For sites where the total radiological

EHQ dose is > 1, strontium-90 is the primary dose contributor. Table 4-5 provides a comparison of the contaminants, which exceed an EHQ of one, for the individual waste sites.

4.2.2 Summary of Key Uncertainties in the Ecological Evaluation

The uncertainty in contaminant concentrations for the ecological evaluation is related to the accuracy of the data. Uncertainty exists in both the contaminants identified and the exposure concentrations. As for the human health assessment, the maximum observed contaminant concentration is used for the evaluation, and this provides a measure of conservativism to the pocket mouse dose model. However, if this number is not realistic, no amount of modeling will overcome this deficiency.

The QRA models the potential exposure of pocket mice suspected to be present in or near the waste site. The issues of concern with regard to ecological risk assessment (particularly qualitative) are uncertainties in using an assortment of environmental variables in risk modeling. Site-specific organisms (e.g., pocket mouse), are identified as being associated with the site, but little, if any, data may exist concerning transfer of contaminants from site-specific organisms. Often, it is necessary to use biological trophic transfer information for related species. The pocket mouse dose model includes a number of factors which are represented in the literature by a range of values, and each contribute to the overall uncertainty. These include factors such as the soil-to-plant contaminant transfer coefficients, the mouse feeding rate, the average pocket mouse body weight, radionuclide biological decay, and radionuclide assimilation factors.

Because uncertainty exists within the dose modeling, the pocket mouse dose model for this QRA builds certain conservatism into the dose estimates. For example, the maximum observed contaminant concentration is used. The exposure scenario assumes uniform soil contamination of the maximum concentration within waste sites and total contamination of mouse foodstuffs. No provision is made for dilution of contaminated foodstuff by noncontaminated foodstuff. The model assumes that the plant roots contact the contaminant and that seed concentration is the same as the plant. Seasonal behavior (hibernation) that can reduce internal exposure and body burden is not considered.

**Figure 4-1 100-FR-1 Operable Unit Waste Site Total Human Health Risks
100-FR-1 Operable Unit Waste Site Human Health Ingestion Risks
100-FR-1 Operable Unit Waste Site Human Health Inhalation Risks**

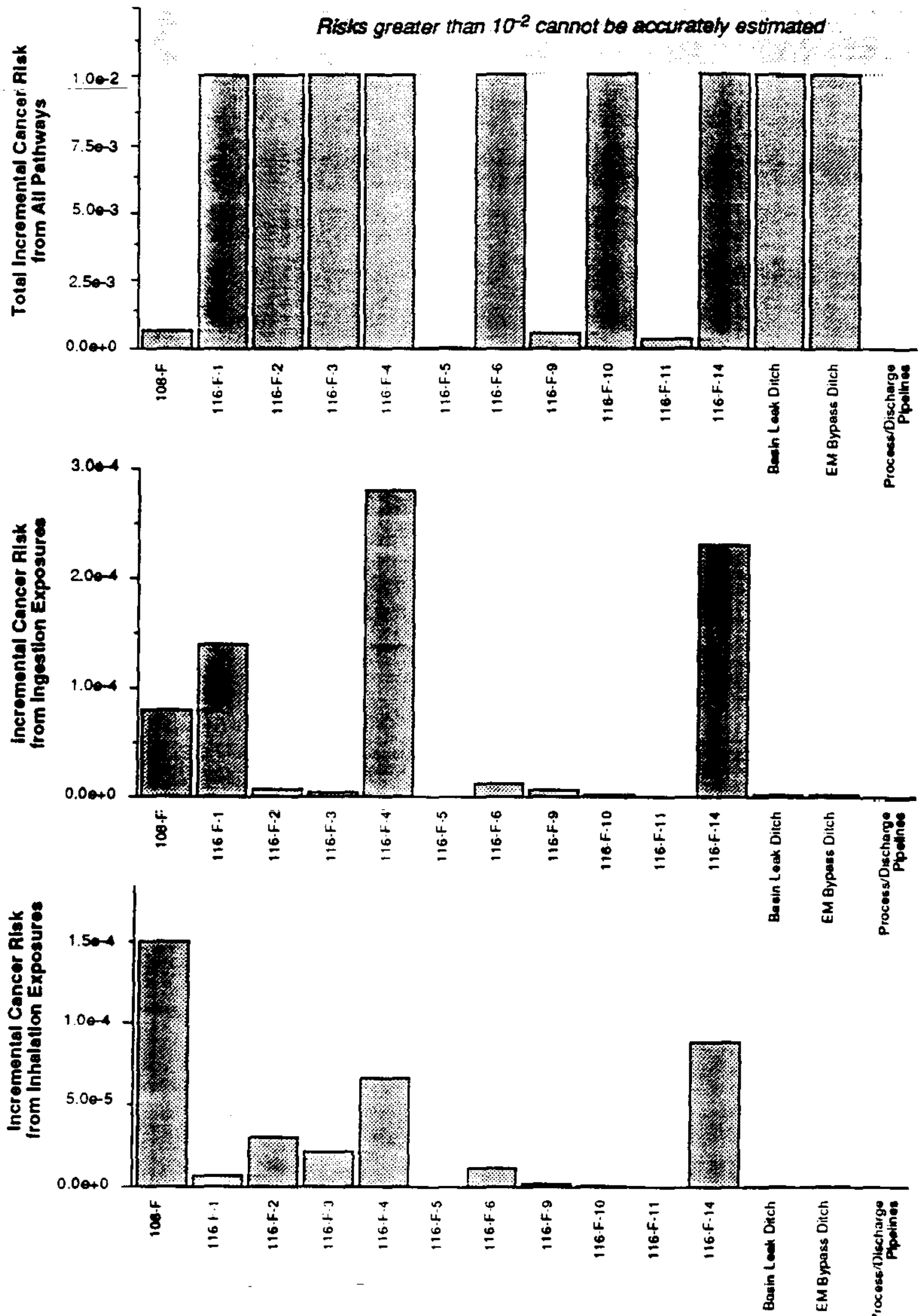

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Figure 4-2 Effect of Radionuclide Decay on Frequent-Use Scenario Site Risks

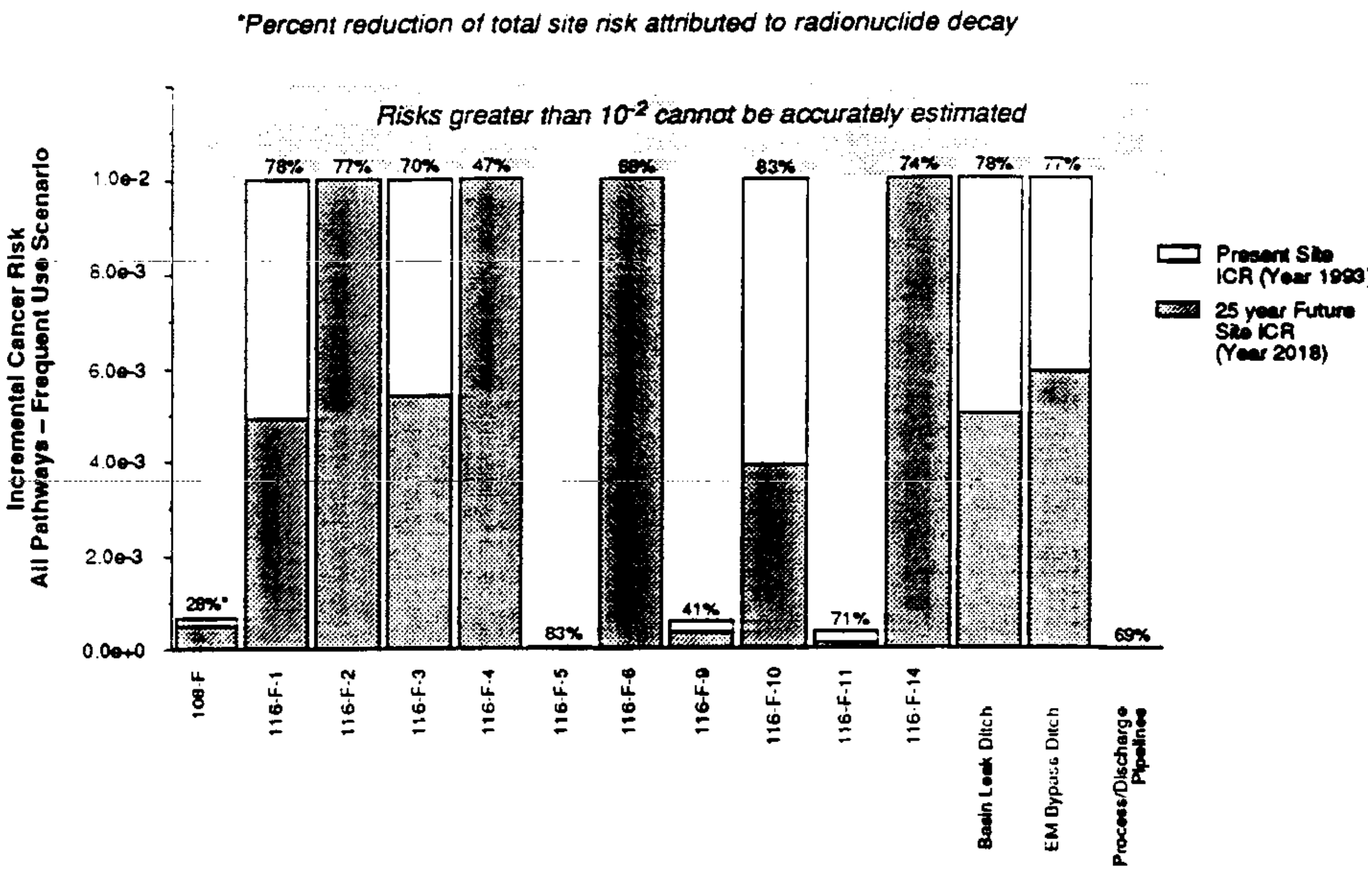

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Figure 4-3 Shielding Effect of Clean-Fill Soil Cover on Occupational Scenario Site Risks

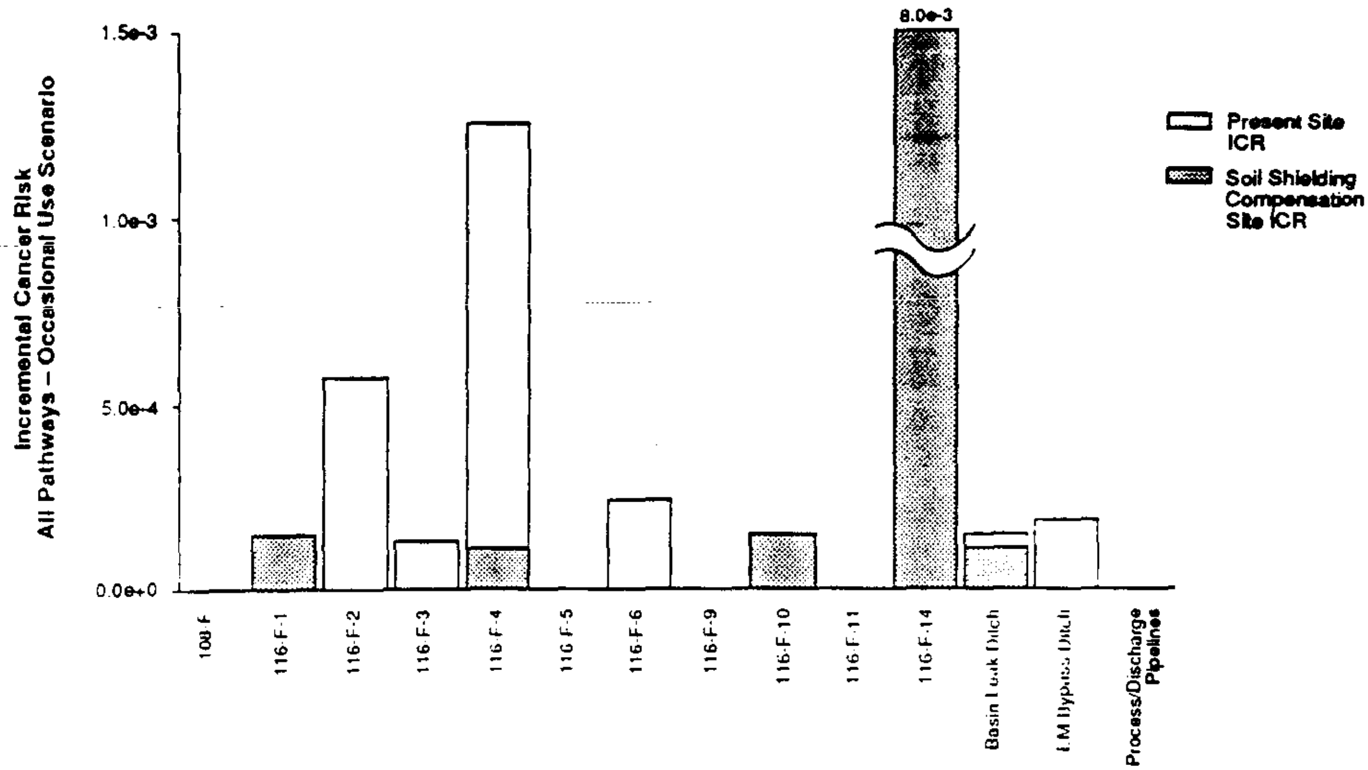

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Table 4-1 Summary of the Human Health Qualitative Risk Assessment for the 100-FR-1 Operable Unit High-Priority and Nonprioritized Waste Sites with Data (page 1 of 2)

Waste Site Designation	Frequent-Use Scenario				Occasional-Use Scenario			
	Qualitative Risk Classification (a)	Major Contaminant	Major Pathway	2018 Qualitative Risk Classification (a,b)	Qualitative Risk Classification (a)	Major Contaminant	Major Pathway	Modified Qualitative Risk Classification (a,c)
108-F French Drain	Medium	Potassium-40 Plutonium-238 Thorium-228 Cesium-137	External Radiation Inhalation Ingestion	Medium	Low	Plutonium-238 Potassium-40 Chromium Thorium-228	External Radiation Inhalation Ingestion	Low
116-F-1 Lewis Canal	High	Europium-152 Cobalt-60 Europium-154	External Radiation	Medium	Medium	Europium-152 Cobalt-60 Europium-154	External Radiation	Medium
116-F-2 (107-F) Basin Overflow Trench	High	Europium-152 Europium-154	External Radiation	High	Medium	Europium-152 Europium-154	External Radiation	Low
116-F-3 (105-F) Fuel Storage Basin Trench	High	Europium-152	External Radiation	Medium	Medium	Europium-152	External Radiation	Low
116-F-4 (105-F) Pluto Crib	High	Cesium-137	External Radiation	High	Medium	Cesium-137	External Radiation	Medium
116-F-5 Ball Washer Crib	Low	Europium-154 Cesium-137	External Radiation	Low	Very Low	Europium-154 Cesium-137	External Radiation	ND
116-F-6 (1608-F) Liquid Waste Disposal Trench	High	Europium-152 Cesium-137 Cobalt-60	External Radiation	High	Medium	Europium-152 Cesium-137 Cobalt-60	External Radiation	Low
116-F-9 PNL Animal Waste Leach Trench	Medium	Potassium-40 Thorium-228 Radium-226 Europium-152	External Radiation	Medium	Low	Potassium-40 Cobalt-60 Thorium-228 Radium-226	External Radiation	Low
116-F-10 (105-F) Dummy Decontamination French Drain	High	Cobalt-60 Europium-152	External Radiation	Medium	Medium	Cobalt-60 Europium-152	External Radiation	ND
116-F-11 (105-F) Cushion Corridor French Drain	Medium	Europium-152 Cesium-137 Europium-154	External Radiation	Medium	Low	Europium-152 Cesium-137 Europium-154	External Radiation	Low

Table 4-1 Summary of the Human Health Qualitative Risk Assessment for the 100-FR-1 Operable Unit High-Priority and Nonprioritized Waste Sites with Data (page 2 of 2)

Waste Site Designation	Frequent-Use Scenario				Occasional-Use Scenario			
	Qualitative Risk Classification (a)	Major Contaminant	Major Pathway	2018 Qualitative Risk Classification (a,b)	Qualitative Risk Classification (a)	Major Contaminant	Major Pathway	Modified Qualitative Risk Classification (a,c)
116-F-14 (107-F) Retention Basin	High	Europium-152 Europium-154 Cesium-137 Cobalt-60	External Radiation	High	Medium	Europium-152 Europium-154 Cesium-137 Cobalt-60	External Radiation	Medium
Process/Discharge Pipelines	Low	Europium-152 Cobalt-60 Cesium-137	External Radiation	Low	Very Low	Europium-152 Cobalt-60 Cesium-137	External Radiation	Very Low
Basin Leak Ditch	High	Europium-152 Cobalt-60 Europium-154	External Radiation	Medium	Medium	Europium-152 Cobalt-60 Europium-154	External Radiation	Medium
EM Bypass Ditch	High	Europium-152 Cobalt-60 Europium-154	External Radiation	Medium	Medium	Europium-152 Cobalt-60 Europium-154	External Radiation	Low

(a) Very Low = Very Low Qualitative Risk; Incremental Cancer Risk (ICR) < 10-6
Low = Low Qualitative Risk, 10-6 < ICR < 10-4
Medium = Medium Qualitative Risk; 10-4 < ICR < 10-2
High = High Qualitative Risk; ICR > 10-2
ND = Not Determined, data unavailable to determine qualitative risk
(b) Qualitative risk when the onset of frequent-use scenario exposures is delayed to the year 2018
(c) Qualitative risk when shielding effects of clean-fill soils are considered when estimating occassional-use scenario external radiation exposures.

Table 4-2 Summary of the Human Health Qualitative Risk Assessment for 100-FR-1 Operable Unit High-Priority and Nonprioritized Waste Sites without Data

Waste Site Designation	Analogous Waste Site (a)	Frequent-Use Scenario			Occasional-Use Scenario		
		Qualitative Risk Classification (b)	Potential Major Contaminant	Potential Major Pathway	Qualitative Risk Classification (b)	Potential Major Contaminant	Potential Major Pathway
116-F-8 (1904-F) Outfall Structure	116-F-14 Retention Basin	High (c)	Europium-154 Europium-152 Cobalt-60 Cesium-137	External Radiation	Medium (c)	Europium-154 Europium-152 Cobalt-60 Cesium-137	External Radiation
116-F-12 (148-F) French Drain	116-F-14 Retention Basin	High (c)	Europium-154 Europium-152 Cobalt-60 Cesium-137	External Radiation	Medium (c)	Europium-154 Europium-152 Cobalt-60 Cesium-137	External Radiation
116-F-13 (1705-F) Experimental Garden French Drain	116-F-14 Retention Basin	High (c)	Europium-154 Europium-152 Cobalt-60 Cesium-137	External Radiation	Medium (c)	Europium-154 Europium-152 Cobalt-60 Cesium-137	External Radiation
128-F-2 Burning Pit	None	Medium (c,d)	Unknown	Ingestion Inhalation	Low (c,d)	Unknown	Ingestion Inhalation
132-F-6 (1608-F) Lift Station Demolition Site	116-F-3 Fuel Storage Basin Trench 116-F-11 Cushion Corridor French Drain	Medium to High	Europium-152 Europium-154 Cesium-137	External Radiation	Low to Medium	Europium-152 Europium-154 Cesium-137	External Radiation
PNL Outfall Structure	116-F-9 PNL Animal Waste Trench	Medium (c)	Potassium-40 Radium-226 Thorium-232 Europium-152	External Radiation	Low (c)	Europium-152 Potassium-40 Radium-226 Thorium-232	External Radiation
Pre-Reactor Coolant Water Facilities	116-F-14 Retention Basin (Chemical) 116-F-5 Ball Washer Crib (Radionuclide)	Low (c)	Europium-154 Cesium-137 Chromium	External Radiation	Very Low (c)	Europium-154 Cesium-137 Chromium	External Radiation
UN-100-F1	116-F-9 PNL Animal Waste Trench	Medium (c)	Potassium-40 Thorium-228 Radium-226 Europium-152	External Radiation	Low (c)	Potassium-40 Thorium-228 Radium-226 Cobalt-60	External Radiation

(a) Selection of Analogous Waste Sites Described in Chapter 2.0 of the 100-FR-1 QRA Report (WHC, 1993a).
(b) Very Low = Very Low Qualitative Risk; Incremental Cancer Risk (ICR) < 10-6
Low = Low Qualitative Risk; 10-6 < ICR < 10-4
Medium = Medium Qualitative Risk; 10-4 < ICR < 10-2
High = High Qualitative Risk; ICR > 10-2
(c) Risk Category may reflect an upper bound of potential risks at this waste site.
(d) Qualitative risk classification is based on the highest risk category for chemical contaminants of potential concern from waste sites characterized by analytical data.

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Table 4-3 Environmental Hazard Quotients Summary for Radionuclides by Waste Site

Waste Site	Dose Rate Exceeds 1 rad/day (EHQ of 1) 0-6 feet	Dose Rate Exceeds 1 rad/day (EHQ of 1) 0-15 feet
108-F French Drain	No	No
116-F-1 Lewis Canal	No	No
116-F-2 Basin Overflow Trench	No	No
116-F-3 Fuel Storage Basin Trench	No	No
116-F-4 Pluto Crib*	Yes	Yes
116-F-5 Ball Washer Crib	NDA	No
116-F-6 Liquid Waste Disposal Trench	No	No
116-F-9 Animal Waste Leach Trench	No	No
116-F-10 Dummy Decontamination French Drain	NDA	No
116-F-11 Cushion Corridor French Drain	No	No
116-F-14 Retention Basin	No	No
Process Discharge Pipeline	No	No
Basin Leak Ditch	No	No
EM Bypass Ditch	No	No

* = Based upon 116-F-4 borehole data, prior to the 100 Area Excavation Treatability Test (DOE-RL 1994c).
NDA = No data available
EHQ = environmental hazard quotient

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Table 4-4 Environmental Hazard Quotients Summary for Nonradiological Contaminants Which Exceed Hanford Background by Waste Site

Waste Site	Dose Rate Exceeds NOEL (EHQ of 1) 0-6 feet	Dose Rate Exceeds NOEL (EHQ of 1) 0-15 feet
108-F French Drain[a] (lead, selenium, zinc copper)	Yes	Yes
116-F-1 Lewis Canal (arsenic, cadmium, lead, zinc)	Yes	Yes
116-F-2 Basin Overflow Trench (cadmium, zinc)	No	Yes
116-F-3 Fuel Storage Basin Trench (lead, zinc, mercury [0-15 ft only], barium)	Yes	Yes
116-F-4 Pluto Crib* (barium)	Yes	Yes
116-F-5 Ball Washer Crib	NDA	NDA
116-F-6 Liquid Waste Disposal Trench (zinc)	No	Yes
116-F-9 Animal Waste Leach Trench (silver, zinc)	No	Yes
116-F-10 Dummy Decontamination French Drain	NDA	NDA
116-F-11 Cushion Corridor French Drain	NDA	NDA
116-F-14 Retention Basin (cadmium, zinc)	Yes	Yes
Process Discharge Pipelines	NDA	NDA
Basin Leak Ditch	NDA	NDA
EM Bypass Ditch	NDA	NDA

* = Based upon 116-F-4 borehole data, prior to the 100 Area Excavation Treatability Test (DOE-RL 1994c).
NDA = No data available
EHQ = environmental hazard quotient
NOEL = no observable effects level

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Table 4-5 Comparison of Contaminants (Exceeding the EHQ) Between Sites

WASTE SITE	Ag	As	Cd	Cu	Ba	Hg	Se	Pb	Zn	Radionuclide
108 French Drain				X			X	X	X	
116-F-1 Lewis Canal		X	X					X	X	
116-F-2 Basin Overflow			X						X	
116-F-3 Fuel Storage Basin Trench					X	X		X	X	
116-F-4 Pluto Crib*					X					X
116-F-6 Liquid Waste Disposal Trench									X	
116-F-9 Animal Waste Leach Trench	X								X	
116-F-14 Retention Basin			X						X	

* = Based upon 116-F-4 borehole data, prior to the 100 Area Excavation Treatability Test (DOE-RL 1994c).
EHQ = environmental hazard quotient

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5.0 RECOMMENDATIONS

The primary purpose of the LFI report is to recommend those high-priority sites that should remain as candidates on the IRM path and those high-priority sites which should not remain as candidates for the IRM path. Sites that are not recommended as candidates for an IRM will be addressed in the final remedy selection process. These recommendations are generally independent of future land-use scenarios.

5.1 HIGH-PRIORITY SITE IRM CANDIDATE EVALUATION CRITERIA

The 100-FR-1 high-priority sites were evaluated using the following criteria to identify those sites where continued IRM candidacy is recommended:

- the 100-FR-1 QRA (WHC 1993)
- an assessment of the waste site conceptual model
- identification of any ARAR exceedance for vadose zone contaminants
- an evaluation of site-specific contaminant impact on groundwater
- identification of sites where natural attenuation by the year 2018 may reduce risks and mitigate contamination.

5.1.1 Qualitative Risk Assessment

The QRA provides risk estimates for human health and for adverse ecological effects. Human health risks, specifically ICR, for the high-priority sites were developed in the QRA using two scenarios: frequent-use and occasional-use. The occasional-use risk values are used to evaluate the continued candidacy of high-priority sites for IRM. The qualitative risk estimations presented in Table 5-3 are grouped into high (ICR >1E-02), medium (ICR >1E-04 to 1E-02), low (ICR 1E-06 to 1E-04), and very low (ICR <1E-06) risk categories based on results presented in Chapter 3 of the 100-FR-1 QRA (WHC 1993). Sites that pose medium or high risks to human health under the occasional-use scenario are recommended to continue as IRM candidates.

Environmental hazard quotient ratings are from the qualitative ecological risk assessment that was performed in the QRA. Sites that have an EHQ rating >1 for radionuclides or nonradiological constituents, present potentially adverse ecological impact and are recommended to continue as IRM candidates.

5.1.2 Conceptual Model

The conceptual model for the waste site includes sources of contamination, types of contaminants, nature and extent of contamination in each affected media, known and potential routes of migration, known or potential human and environmental receptors, and the general understanding of the site structure/process. This information is included in Chapter 3 of the 100-FR-1 Work Plan (DOE-RL 1992a) and has been revised using data obtained during the LFI. Table 5-1 presents sources of contamination, types of contaminants, nature and extent of contamination in each affected media, and the general understanding of the structure/process for each high-priority waste site. Figure 5-1 presents the known and potential routes of migration, known or potential human and environmental receptors for the operable unit. If the conceptual model of a site is incomplete, the site is recommended to remain as an IRM candidate while the data needed to complete the model are collected. After the data are available the site will be reevaluated for continued candidacy for an IRM. The additional data may be obtained through limited field sampling.

5.1.3 Applicable or Relevant and Appropriate Requirements

The Washington State MTCA Method B concentrations are potential ARAR for soil contamination, as discussed in Section 3.20 of this report and in the *100 Area Feasibility Study, Phases 1 and 2* (DOE-RL 1992c). Model Toxics Control Act Method B regulatory limits for soil contaminant concentrations are utilized since they are the standard approach and are conservative. Table 5-2 lists the Hanford Site background 95% UTL values for metallic constituents in soils and MTCA Method B guidelines for soil. Sites that have concentrations of contaminants which exceed this potential chemical-specific ARAR are recommended to continue as IRM candidates.

5.1.4 Current Impact on Groundwater

The probability of current impact on groundwater is evaluated for each site by comparing groundwater contaminant concentrations from monitoring wells located upgradient and downgradient of each specific site, where wells are available. Concentrations of chromium and strontium-90 in upgradient and downgradient wells are compared. Groundwater contaminant concentrations in a downgradient well that are higher than in an upgradient well indicate current impact to groundwater. Sites that are impacting groundwater are recommended to continue as IRM candidates.

5.1.5 Potential for Natural Attenuation

The potential for the contaminants at a site to be reduced by natural attenuation, i.e., radioactive decay by the year 2018, may be a consideration at sites where radionuclides with half lives <30 years are the primary contaminants and external exposure is the only pathway. Sites with excess risk attributed to radionuclides with half lives <30 years, i.e., cobalt-60, cesium-137, europium-152, and europium-154, have potential for natural reduction of risk through radioactive decay. Natural attenuation is not a consideration for sites contaminated by metals, by radionuclides with half-lives >30 years, or where multiple exposure pathways drive the risk.

5.2 HIGH-PRIORITY SITE IRM CANDIDATE RECOMMENDATIONS

The final selection of IRM sites, and priority of action are decisions left to the Tri-Agreement signatories. Factors that the Tri-Party Agreement signatories may consider in the selection and prioritization of IRM sites include:

- impact of IRM actions in relation to the 100 Area Environmental Impact Statement, e.g., disposition of the reactors
- access control
- relation to the IRM program plan recommendations
- land use
- point of compliance
- time of compliance
- feasibility
- bias-for-action
- threat to human health and the environment.

The high-priority sites recommended to continue as IRM candidates are identified in the "IRM Candidate" column of the Table 5-3. The recommendations are discussed below.

5.2.1 116-F-1 Lewis Canal

The 116-F-1 lewis canal is recommended to continue as an IRM candidate because the human health risk is medium, and the EHQ is >1. No contaminants were found in the 116-F-1 investigation that exceeded MTCA Method B guidelines. This site's impact on the groundwater could not be determined due to the lack of an upgradient monitoring well, however, low levels of chromium, and no detections of strontium-90 in the downgradient well indicate that this site is probably not currently impacting the groundwater. Natural attenuation by the year 2018, i.e., radioactive decay, may not mitigate risk posed by the principle contaminants and associated exposure pathway.

5.2.2 116-F-2 Basin Overflow Trench

The 116-F-2 basin overflow trench is recommended to continue as an IRM candidate because the human health risk is medium, and the EHQ is >1. No contaminants were found in the 116-F-2 investigation that exceeded MTCA Method B guidelines. This site's impact on the groundwater could not be determined due to the lack of an upgradient monitoring well. Natural attenuation by the year 2018, i.e., radioactive decay, may not mitigate risk posed by the principle contaminants and associated exposure pathway. The EM bypass ditch (described in Section 3.2) is an associated site that was not prioritized as a high-priority or low-priority site. The 100-FR-1 QRA (WHC 1993) did, however, calculate a medium human health risk for this site using the occasional-use scenario.

5.2.3 116-F-3 Fuel Storage Basin Trench

The 116-F-3 fuel storage basin trench is recommended to continue as an IRM candidate because the human health risk is medium, and the EHQ is >1. No contaminants were found in the 116-F-3 investigation that exceeded MTCA Method B guidelines. This site's impact on the groundwater could not be determined due to the lack of an upgradient monitoring well. Natural attenuation by the year 2018, i.e., radioactive decay, may not mitigate risk posed by the principle contaminants and associated exposure pathway.

5.2.4 116-F-4 Pluto Crib

The 116-F-4 pluto crib is not recommended to continue as an IRM candidate. Contamination was removed as a part of the *100 Area Excavation Treatability Test Plan* (DOE-RL 1994e). This site's impact on the groundwater could not be determined due to the lack of an upgradient monitoring well, however, low levels of chromium, and no detections of strontium-90 in the downgradient well indicate that this site is probably not currently impacting the groundwater.

5.2.5 116-F-6 Liquid Waste Disposal Trench

The 116-F-6 liquid waste disposal trench is recommended to continue as an IRM candidate because the human health risk is medium, and the EHQ is >1. No contaminants were found in the 116-F-6 investigation that exceeded MTCA Method B guidelines. It does not appear that this site is currently impacting groundwater because the chromium and strontium-90 values in downgradient well 199-F-47 were not greater than the values found in upgradient well 199-F-6. Natural attenuation by the year 2018, i.e., radioactive decay, may not mitigate risk posed by the principle contaminants and associated exposure pathway.

5.2.6 116-F-9 Animal Waste Leach Trench

The 116-F-9 animal waste leach trench is recommended to continue as an IRM candidate because the EHQ is >1. The human health risk for site 116-F-9 is low. No contaminants were found to exceed MTCA Method B guidelines. It appears that site 116-F-9 is not currently impacting groundwater because concentrations of chromium and strontium-90 are considerably higher in the upgradient well than the values found in the downgradient well. Natural attenuation by the year 2018, i.e., radioactive decay, may not mitigate risk posed by the principle contaminants and associated exposure pathway.

5.2.7 116-F-14 Retention Basin

The 116-F-14 retention basin is recommended to continue as an IRM candidate because the human health risk is medium, and the EHQ is >1. No contaminants were found in the 116-F-14 investigation that exceeded MTCA Method B guidelines. It appears that 116-F-14 site is currently impacting groundwater because the strontium-90 values in downgradient well 199-F5-3 were considerably higher than the values found in upgradient well 199-F5-46. Natural attenuation by the year 2018, i.e., radioactive decay, may not mitigate risk posed by the principle contaminants and associated exposure pathway.

5.2.8 108-F French Drain

The 108-F french drain is recommended to continue as an IRM candidate because the EHQ is >1. The human health risk for the 108-F french drain is low. No contaminants were found to exceed MTCA Method B guidelines. It appears that this site is possibly impacting groundwater because concentrations of strontium-90 are slightly higher in downgradient well 199-F5-45 than the values found in upgradient well 199-F5-4, however, further investigation of groundwater contamination is needed to accurately determine the current impact of this site to the groundwater. Natural attenuation by the year 2018, i.e., radioactive decay, may not mitigate risk posed by the principle contaminants and associated exposure pathway.

5.2.9 116-F-5 Ball Washer Crib

The 116-F-5 ball washer crib is not recommended to continue as an IRM candidate. The human health risk for this site is very low and the EHQ rating is <1. Because this site used historical data for its evaluation, no data were available for comparison to MTCA Method B. No monitoring well is located in close enough proximity to this site TBC an upgradient well, therefore, the impact to groundwater from this site could not be determined. Natural attenuation by the year 2018, i.e., radioactive decay, will reduce the risk posed by the principle contaminants and associated exposure pathway.

5.2.10 116-F-8 Outfall Structure

The 116-F-8 outfall structure is recommended to continue as an IRM candidate. Because of the uncertainty regarding the concentrations of contaminants that this site received, the conceptual model is incomplete. Limited field sampling is needed to resolve the uncertainties. Once the data are available this site should be evaluated for continued consideration as an IRM candidate.

5.2.11 116-F-10 Dummy Decontamination French Drain

The 116-F-10 dummy decontamination french drain is recommended to continue as an IRM candidate because the human health risk is medium, although cobalt-60 and europium-152 are the major contributors to risk, both of which have potential for natural attenuation by the year 2018. The external exposure pathway is the major contributor to risk. No data were available in the 0 ft to 6 ft bls interval, therefore, no risk reduction from the shielding effect of clean-fill soils could be estimated. The EHQ rating for this site is <1. Because this site used historical data for its evaluation, no data were available for comparison to MTCA Method B guidelines. It appears that 116-F-10 site is not currently impacting groundwater because the strontium-90 values in upgradient well 199-F8-2 were higher than the values found in downgradient well 199-F5-47 and the chromium values were similar between the upgradient and downgradient wells.

5.2.12 116-F-11 Cushion Corridor French Drain

The 116-F-11 cushion corridor french drain is not recommended to continue as an IRM candidate. The human health risk is low and the EHQ rating for this site is <1. Because this site used historical data for its evaluation, no data were available for comparison to MTCA Method B guidelines. No monitoring well is located in close enough proximity to this site TBC an upgradient well, therefore, the impact on groundwater from this site could not be determined. Natural attenuation by the year 2018, i.e., radioactive decay, will reduce the risk posed by the principle contaminants and associated exposure pathway.

5.2.13 116-F-12 French Drain

The 116-F-12 french drain is recommended to continue as an IRM candidate. Because of the uncertainty regarding the contaminants and the concentrations of contaminants that this site received, the conceptual model is incomplete. Limited field sampling is recommended to resolve the uncertainties. Once the data are available, this site should be evaluated for continued consideration as an IRM candidate.

5.2.14 116-F-13 Experimental Garden French Drain

The 116-F-13 experimental garden french drain is recommended to continue as an IRM candidate. Because of the uncertainty regarding the contaminants and the concentrations of contaminants that this site received, the conceptual model is incomplete. Limited field sampling is recommended to resolve the uncertainties. Once the data are available, this site should be evaluated for continued consideration as an IRM candidate.

5.2.15 Process/Discharge Pipelines

The process/discharge pipelines are not recommended to continue as an IRM candidate. The human health risk for this site is very low and the EHQ rating is <1. Because this site used historical data and analogous data for its evaluation, no data were available for comparison to MTCA Method B. Because of the extensive nature of the pipelines and their proximity to other waste sites, a groundwater assessment based upon current monitoring wells is not possible. Natural attenuation by the year 2018, i.e., radioactive decay, will reduce the risk posed by the principle contaminants and associated exposure pathway.

5.2.16 UN-100-F-1

The UN-100-F-1 unplanned release site is recommended to continue as an IRM candidate. Because of the uncertainty regarding the contaminants and the concentrations of contaminants that this site received, the conceptual model is incomplete. Limited field sampling is recommended to resolve the uncertainties. Once the data are available, this site should be evaluated for continued consideration as an IRM candidate.

5.2.17 132-F-6 Lift Station Demolition Site

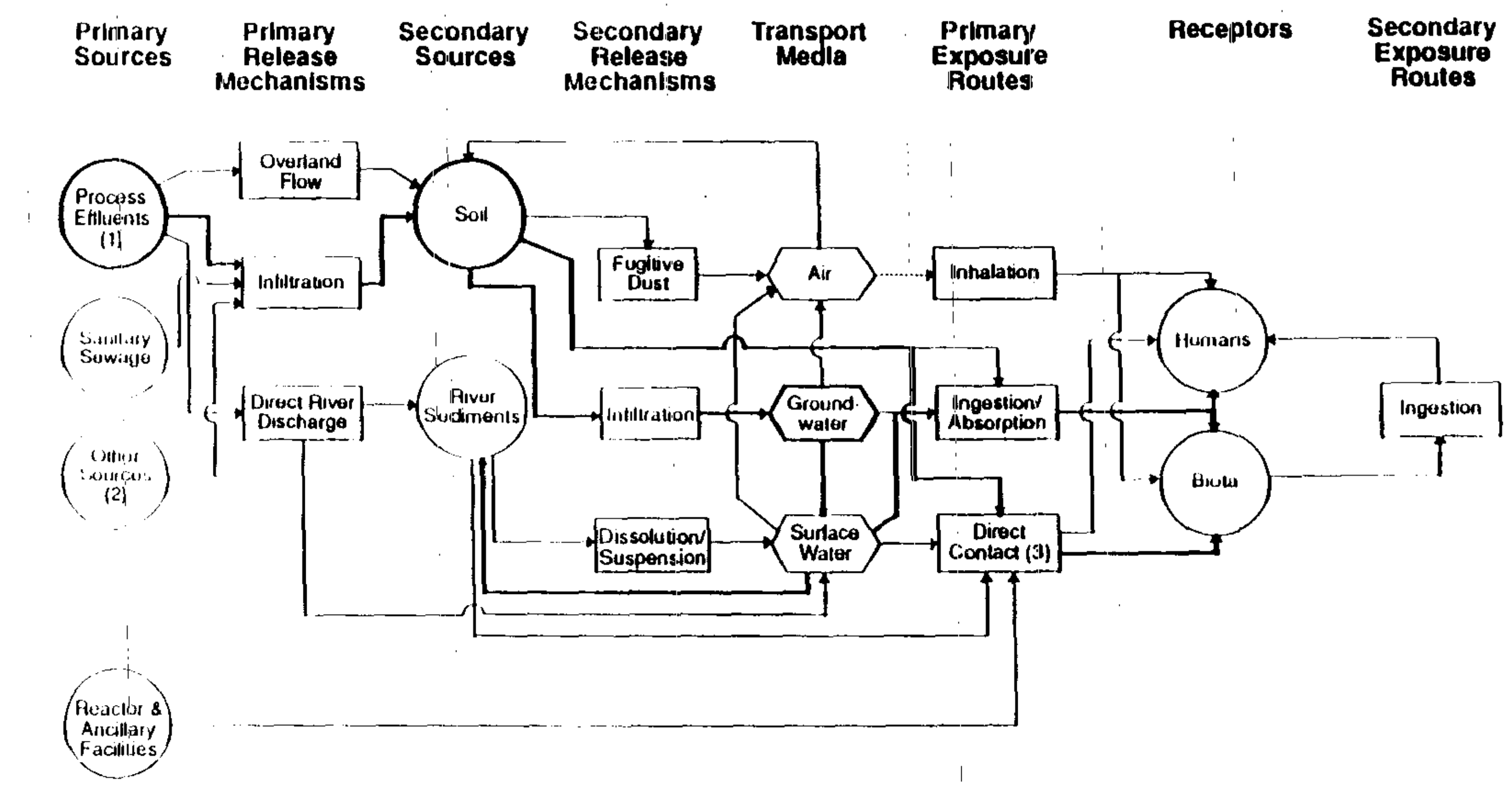
The 132-F-6 lift station demolition site is recommended to continue as an IRM candidate. Because of the uncertainty regarding the contaminants and the concentrations of contaminants that this site received, the conceptual model is incomplete. Limited field sampling is recommended to resolve the uncertainties. Once the data are available, this site should be evaluated for continued consideration as an IRM candidate.

5.2.18 PNL Outfall Structure

The PNL outfall structure is recommended to continue as an IRM candidate. Because of the uncertainty regarding the contaminants and the concentrations of contaminants that this site received, the conceptual model is incomplete. Limited field sampling is recommended to resolve the uncertainties. Once the data are available, this site should be evaluated for continued consideration as an IRM candidate.

5.2.19 Nonprioritized Sites

The basin leak ditch (described in Section 3.7) and the EM bypass ditch (described in Section 3.2) are associated sites that were not prioritized. The 100-FR-1 QRA (WHC 1993) did, however, calculate a medium human health risk for these site's using the occasional-use scenario. Only sites listed in the 100-FR-1 Work Plan (DOE-RL 1992a) as being high-priority, were addressed by the LFI. The risks associated with these sites indicate that they should be placed on the IRM pathway, pending collection of confirmatory data.



LEGEND

→ Potential Exposure Pathway

→ Potential Primary Exposure Pathway

○ ⬭ Primary contaminant sources and known contaminated media

(1) Includes all facilities that received process effluents, including pipelines, basins, cribs, trenches, french drains, and outfall structures.

(2) Includes other sources within limited existing information.

(3) Includes exposure to radiation.

Figure 5-1 Conceptual Model Contaminant Exposure Pathway for the 100-FR-1 Operable Unit

Table 5-1 Conceptual Model of 100-FR-1 High-Priority Sites: Structure/Process, Source and Type of Contaminants, and Nature and Extent of Contamination (page 1 of 6)

Site	Structure/Process	Contaminant Source	Contaminants of Potential Concern	Nature and Extent of Contamination
116-F-1 Lewis Canal	Effluent disposal drainage trench, unlined - 914m x 12m x 3m deep	Received liquid wastes from F Reactor, 190-F buildings and decontamination wastes from 189-F buildings. Also received 100 kg sodium dichromate and 10,000 of sulfamic acid	Methylene chloride, toluene, acetone, bis(2-ethylhexyl)phthalate, As, Pb, Zn, C-14, K-40, Sr-90, Ra-226, Th-228, Th-232, U-233/234, U-238, Pu-239/240	Soil contamination at least 20 ft
116-F-2 Basin Overflow Trench	Effluent overflow trench, unlined - 91m x 15m x 4.5m	Received reactor cooling water from the retention basin during reactor outages. Also received 600 kg of sodium dichromate	Ba, Cd, Cr, Zn, C-14, K-40, Co-58, Co-60, Sr-90, Cs-137, Eu-152, Eu-154, Eu-155, Ra-226, Th-228, Th-232, U-233/234, U-238, Pu-238, Pu-239/240, Am-241	Soil contamination at least 32 ft
116-F-3 Fuel Storage Basin Trench	Effluent disposal trench, unlined - 30m x 6m x 2.4m	Received reactor effluent during fuel classing failure, and sludge from fuel storage basin, also received 4 kg of sodium dichromate	Toluene, fluoranthene, pyrene, toxaphene, aroclor-1254, Ba, Pb, Cr, Hg, Zn, K-40, Co-60, Cs-137, Eu-152, Eu-154, Ra-226, Th-228, Th-232, U-233/234, U-238, Pu-238, Pu-239/240, Am-241	Soil contamination to 12 ft

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Table 5-1 Conceptual Model of 100-FR-1 High-Priority Sites: Structure/Process, Source and Type of Contaminants, and Nature and Extent of Contamination
(page 2 of 6)

Site	Structure/Process	Contaminant Source	Contaminants of Potential Concern	Nature and Extent of Contamination
116-F-4 Pluto Crib	Effluent disposal crib 3m x 3m x 3m	Received liquid effluent from the 105 F Reactor during outages due to fuel ruptures. Received .004 kg of sodium dichromate	Methylene chloride, acetone, toluene, 2-butanone, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, K-40, Sr-90, Cs-137, Eu-152, Eu-154, Eu-155, Ra-226, Th-228, Th-232, U-233/234, U-235, U-238, Pu-238, Pu-239/240, Am-241	Soil contamination to at least 28.6 ft
116-F-6 Liquid Waste Disposal Trench	Effluent Disposal Trench, unlined - 90m x 30m x 3m	Received cooling water while maintenance were performed on the effluent. Received 300 kg of sulfamic acid	Methylene chloride, acetone, toluene, benzene, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, K-40, Co-60, Sr-90, Cs-137, Eu-152, Eu-154, Ra-226, Th-228, Th-232, U-233/234, U-238, Pu-238, Pu-239/240, Am-241	Soil contamination to 21 ft

Table 5-1 Conceptual Model of 100-FR-1 High-Priority Sites: Structure/Process, Source and Type of Contaminants, and Nature and Extent of Contamination (page 3 of 6)

Site	Structure/Process	Contaminant Source	Contaminants of Potential Concern	Nature and Extent of Contamination
116-F-9 PNL Animal Waste Leach Trench	Waste water disposal trench, "Y" shaped trench with the long leg 120m x 5m x 3m, and the short leg 30m x 5m x 3m	Received waste water from the cleaning of animal pens in the experimental animal farm	Methylene chloride, acetone, toluene, 2-butanone, 4-methyl-2-pentanone, bis(2-ethylhexyl)phthalate, alpha-chlordane, gamma-chlordane, K-40, Sr-90, Cs-137, Ra-226, Th-228, Th-232, U-233/234, U-238	Soil contamination to 25 ft
116-F-14 Retention Basin	Retention basin reinforced - 137m x 70m x 7.3m	Held cooling water effluent from F Reactor for cooling/delay before release to the Columbia River, large leaks of effluent to the soil	Methylene chloride, acetone, toluene, chloroform, 2-butanone, 4-methyl-2-pentanone, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, diethylphthalate, C-14, Co-60, Sr-90, Cs-137, Eu-152, Eu-154, Eu-155, Ra-226, Th-228, Th-232, U-233/234, U-238, Pu-238, Pu-239/240, Am-241	Soil contamination to 25 ft Groundwater contamination

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Table 5-1 Conceptual Model of 100-FR-1 High-Priority Sites: Structure/Process, Source and Type of Contaminants, and Nature and Extent of Contamination

Site	Structure/Process	Contaminant Source	Contaminants of Potential Concern	Nature and Extent of Contamination
108-F French Drain	Biology building french drain	Received condensate from laboratory hoods in the 108-F Biology building	Toluene, bis(2-ethylhexyl)phthalate, aroclor-1254, aroclor-1260, Cr, Cu, Pb, Zn, K-40, Cs-137, Eu-152, Ra-226, Th-228, Th-232, U-233/234, U-238, Pu-238, Pu-239/240, Am-241	Soil contamination to at least 4.5 ft possible groundwater contamination
116-F-5 Ball Washer Crib	Liquid waste crib, unlined - 3m x 3m x 3m	Receive liquid waste containing nitric acid derived from the decontamination of boron stell balls.	From historical data: Cs-137, Eu-154	low levels of soil contamination based solely on historical data
116-F-8 Outfall Structure	Process effluent outfall structure 8m x 4m x 8m	Received effluent from the 116-F-14 Retention Basin	Analogous data from process/discharge pipelines Co-60, Cs-137, Eu-152, U-238	Nature and vertical extent of contamination is unknown
116-F-10 Dummy Decontamination French Drain	Liquid waste french drain 1m diameter, 3m deep	Received radioactive water rinses and spent nitric acid from the decontamination of fuel element spacers. Received 2000 kg of sodium dichromate, 2000 kg of sodium oxalate, 2000 kg of sodium sulfamate	Based solely on historical data: Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, U-238	Soil contamination to 20 ft based on historical data

Table 5-1 Conceptual Model of 100-FR-1 High-Priority Sites: Structure/Process, Source and Type of Contaminants, and Nature and Extent of Contamination (page 5 of 6)

Site	Structure/Process	Contaminant Source	Contaminants of Potential Concern	Nature and Extent of Contamination
116-F-11 Cushion Corridor French Drain	Liquid waste french drain 1m diameter, 1m deep	Received cushion corridor contamination wastes	Based solely upon historical data from borehole 30 m away from 116-F-11: Co-60, Cs-137, Eu-152, Eu-154	Soil contamination based on historical data.
116-F-12 French Drain	Liquid waste french drain 1m diameter x 2m deep	Received liquid pump prime from the lift station	Not sampled. Contaminants are likely similar to those found in the 116-F-14 Retention Basin.	Nature and vertical extent of contamination is unknown.
116-F-13 Experimental Garden French Drain	Liquid waste french drain, 1m diameter x 1m deep	Received effluent from radio-botany experiments conducted in the 1705-F facilities	Unknown	Nature and vertical extend of contamination is unknown. No impact to groundwater is being observed.
Process/Discharge Pipelines	Pipe diameter 152cm, both above and below ground sections	Transferred cooling water from the F Reactor to the 116-F-14 Retention Basin	Historical data: Co-60, Cs-137, Eu-152, U-238	Extensive history of leakage suggests soil and groundwater contamination

Table 5-1 Conceptual Model of 100-FR-1 High-Priority Sites: Structure/Process, Source and Type of Contaminants, and Nature and Extent of Contamination (page 6 of 6)

Site	Structure/Process	Contaminant Source	Contaminants of Potential Concern	Nature and Extent of Contamination
UN-100-F-1	Unplanned relase	141-C Hog Barn process sewer line overflowed into surface adjacent to building	Not sampled, contaminants are likely similar to those found in the 116-F-9 Animal Waste Leach trench	Nature and vertical extent of contamination is uknown
132-F-6 Lift Station Demolition Site	Waste water pump station	Pumped reactor waste water from reactor building drains and sumps to effluent line	Not sampled, suspected contaminants include: H-3, C-14, Co-60, Sr-90, Cs-137, Eu-152, Eu-154, and decontamination chemicals such as: sodium fluoride, oxalic acid, nitric acid	Nature and vertical extent of contamination is uknown
PNL Outfall Structure	Outfall structure spillway measured 30m long x 3m wide	Received liquid waste from animal pens and cooling water used at the 116-F- Aquatic Biology laboratory	Not sampled, contaminants are likely similar to those found at the 116-F-9 Animal Waste Leach Trench	Nature and vertical extent of contamination is unknown.

Table 5-2 Hanford Site Background 95% Upper Threshold Limits and Model Toxics Control Act Method B Guidelines for Inorganic Analytes

Analyte[a]	95% UTL[b] (mg/kg)	MTCA Method B[c] (mg/kg)
Alkalinity	23,300	N/L
Ammonia	28.2	N/L
Antimony	15.7[d]	32
Arsenic	8.92	24 (.59)[e]
Barium	171	5,600
Beryllium	1.77	400 (0.23)[e]
Cadmium	0.66[d]	40
Chloride	763	N/L
Chromium	27.9	400[f]
Cobalt	19.6	N/L
Copper	28.2	3,200
Fluoride	12	4,800
Lead	14.75	U
Lithium	37.1	N/L
Manganese	612	400
Mercury	1.25	24
Molybdenum	1.4[d]	400
Nickel	25.3	1,600
Nitrate	199	130,000
Nitrite	21[d]	8,000
Ortho-phosphate	16	N/L
Selenium	5[d]	400
Silicon	192	N/L
Silver	2.7	400
Sulfate	1,320	N/L
Thallium	3.7[d]	5.6 - 7.2[g]
Titanium	3,570	N/L
Vanadium	111	560
Zinc	79	24,000
Zirconium	57.3	N/L

Source: DOE-RL 1993a
NL = Not listed in MTCA Human Health Risk Based Method B Formula-Values table for soil
U = Unavailable
[a] Analytes essentially non-toxic in soil are not listed (DOE-RL 1993b). These include aluminum, calcium, iron, magnesium, potassium, sodium.
[b] 95% confidence limit of the 95th percentile of the data distribution
[c] Non-carcinogen risk-based concentration, no carcinogen risk except as shown in parenthesis
[d] Limit of detection
[e] Carcinogen risk-based concentration in parenthesis
[f] Hexavalent chromium
[g] Range of risk-based concentrations for thallium compounds

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Table 5-3 IRM Recommendations for 100-FR-1 High-Priority Sites

Waste Site	Qualitative Risk Estimation		Conceptual Model	Exceeds ARAR	Possible Current Impact on Groundwater	Potential for Natural Attenuation by 2018	IRM Candidate yes/no
	Occasional-Use Scenario	EHQ > 1					
116-F-1 Lewis Canal	Medium	Yes	Adequate	No	Unknown	No	Yes
116-F-2 Basin Overflow Trench	Medium	Yes	Adequate	No	Unknown	No	Yes
116-F-3 Fuel Storage Basin Trench	Medium	Yes	Adequate	No	Unknown	No	Yes
116-F-4 Pluto Crib **	Medium**	Yes**	Adequate	NA	Unknown	NA	No **
116-F-6 Liquid Waste Disposal Trench	Medium	Yes	Adequate	No	No	No	Yes
116-F-9 PNL Animal Waste Leach Trench	Low	Yes	Adequate	No	No	No	Yes
116-F-14 Retention Basin	Medium	Yes	Adequate	No	Yes	No	Yes
108-F French Drain	Low	Yes	Adequate	No	Yes	No	Yes
116-F-5 Ball Washer Crib	Very Low	No	Adequate	Unknown	No	Yes	No
116-F-8 Outfall Structure	Medium*	--	Incomplete*	Unknown*	Unknown*	Unknown*	Yes*
116-F-10 Dummy Decontamination French Drain	Medium	No	Adequate	Unknown	No	Yes	Yes
116-F-11 Cushion Corridor French Drain	Low	No	Adequate	Unknown	Unknown	Yes	No
116-F-12 French Drain	Medium*	--	Incomplete*	Unknown*	No	Unknown*	Yes*
116-F-13 Experimental Garden French Drain	Medium*	--	Incomplete*	Unknown*	No	Unknown*	Yes*
Process/Discharge Pipelines	Very Low	No	Adequate	Unknown	Unknown	Yes	No
UN-100-F-1	Low*	--	Incomplete*	Unknown*	No	Unknown*	Yes*
132-F-6 Lift Station Demolition Site	Very Low*	--	Incomplete*	Unknown*	Unknown*	Unknown*	Yes*
PNL Outfall Structure	Low*	--	Incomplete*	Unknown*	Unknown*	Unknown*	Yes*

* = Not sampled, conceptual model is considered incomplete, risk is based upon analogous information
** = Qualitative risk reduced/removed by removal of contaminated material as part of the 100 Area Excavation Treatability Test (DOE-RL 1994b) (Qualitative Risk Estimation based upon LFI Borehole Data prior to Treatability Excavation)
-- = Not rated by the qualitative ecological risk assessment
ARAR = Applicable or Relevant and Appropriate Regulation, specifically the Washington state Model Toxics Control Act Method B concentration values for soils (DOE-RL 1992a)
EHQ = Environmental Hazard Quotient calculated by the qualitative ecological risk assessment (WHC 1993)
NA = Not Applicable
Shaded areas indicate driving factors keeping site as IRM candidate

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APPENDIX A

DORIAN AND RICHARDS (1978) SAMPLING RESULTS (DECAYED TO JANUARY 1993)

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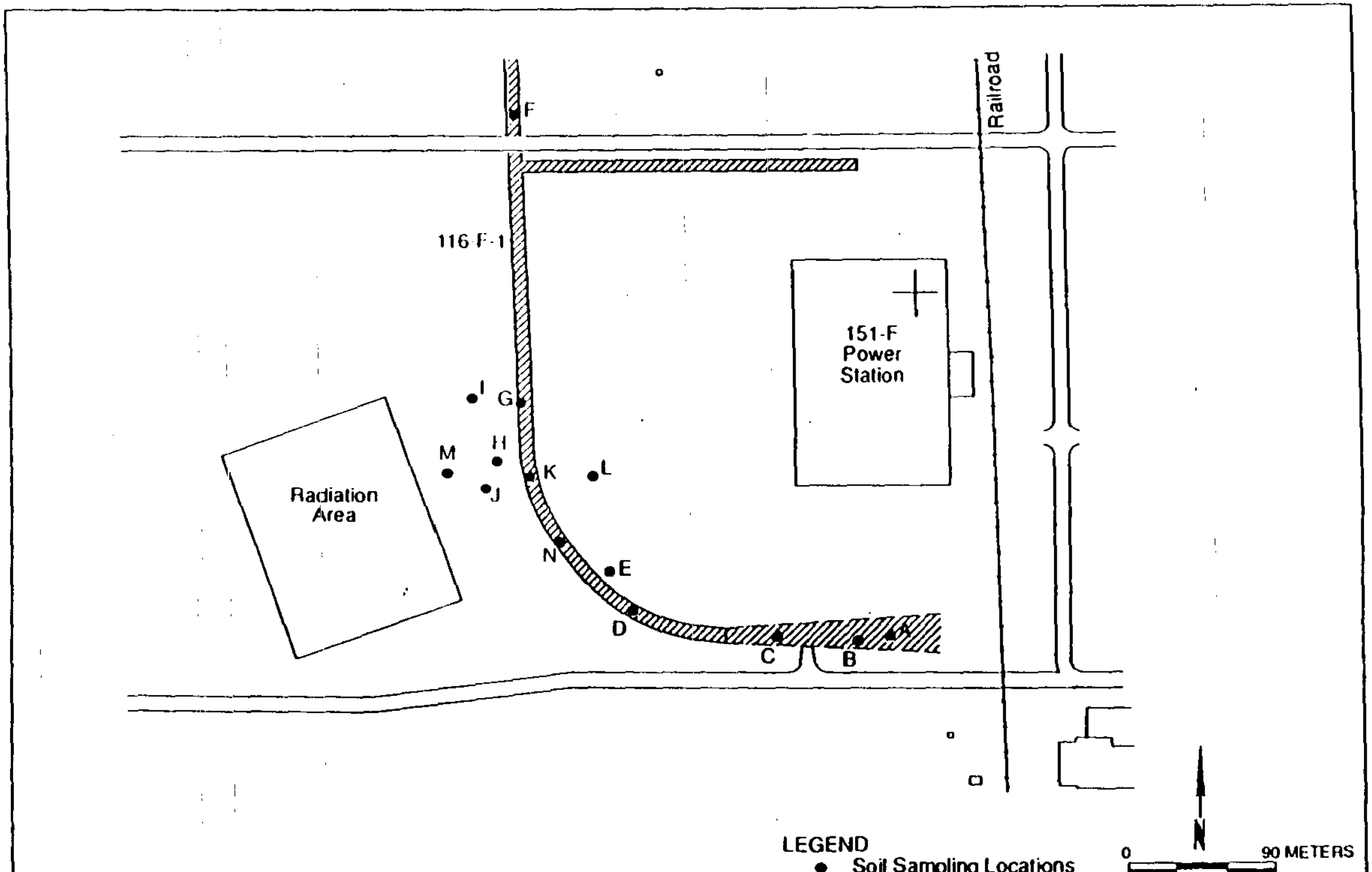
Radionuclide Constituents in Subsurface Soil at the 116-F-1 Lewis Canal

Sample Number	Elev.[b]	Concentrations (pCi/g)											
		^{238}Pu	$^{239/240}$Pu[a]	^{90}Sr	^{3}H	P-11 Scaler c/m	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U[a]
A 5	401.24	*	*	*		<200/10	*	*	*	*	1.1×10^{1}	*	
10		*	1.5×10^{1}	8.6×10^{-2}	6.1×10^{2}	<200/10	*	*	*	*	*	*	1.1×10^{1}
15		*	*	9.3×10^{1}		<200/10	*	*	*	1.4×10^{-4}	*	*	
B 5	401.2	*	*	1.1×10^{1}		<200/15	*	1×10^{2}	*	*	*	*	
10		*	*	2.4×10^{1}	2.6×10^{1}	<200/20	1×10^{1}	5.1×10^{3}	*	*	1.9×10^{2}	*	1.1×10^{1}
15		*	*	9.3×10^{1}		<200/10	*	*	*	*	5.5×10^{-2}	*	
C 5	399.56	*	*	1.5×10^{0}		<200	*	4.6×10^{3}	*	*	*	*	
10		*	*	1.3×10^{0}		<200	*	*	*	1.0×10^{-4}	*	*	
18		*	*	*		<200	7.1×10^{2}	*	*	*	4.5×10^{-2}	*	
D 5	391.38	*	*	6.4×10^{-2}		<200	6.3×10^{1}	1.3×10^{-1}	1.3×10^{-1}	1.3×10^{-4}	9.5×10^{2}	*	
10		*	*	5.7×10^{1}		<200	*	*	*	*	*	*	
E 2-1/2	391.2	*	*	2.1×10^{1}		<200/20	8.4×10^{-2}	*	*	1.7×10^{-4}	1.3×10^{-1}	*	
7-1/2		*	*	6.3×10^{1}	4.6×10^{2}	<200/30	2.7×10^{0}	5.7×10^{-1}	3.1×10^{1}	*	4.9×10^{-1}	*	1.4×10^{1}
F 5	389.9	*	*	5.6×10^{-2}	*	<200/20	2.3×10^{-1}	1.8×10^{2}	9.4×10^{2}	*	1.4×10^{-1}	*	5.4×10^{-2}
10		*	*	1.5×10^{0}		<200/10	*	*	*	*	*	*	
G 3	389.53	*	5.3×10^{1}	3.8×10^{0}	7.7×10^{0}	500	1.1×10^{2}	2.1×10^{1}	3.1×10^{1}	*	2.2×10^{1}	9.1×10^{3}	1.6×10^{1}
5		*	9.9×10^{1}	2.9×10^{1}	8×10^{1}	<200/20	8.8×10^{2}	1.3×10^{2}	*	*	3.7×10^{2}	*	1.3×10^{1}
10		*	*	7.9×10^{3}		<200/15	*	*	*	1.1×10^{-4}		9.3×10^{3}	
H 5	388.05	*	*	*		<200/10	1.1×10^{1}	1.7×10^{2}	*	*	*	*	
10		*	*	8.6×10^{-2}	9.2×10^{2}	<200/20	*	*	*	*	*	1.1×10^{-2}	8.3×10^{2}
15		*	*	4.5×10^{-2}		<200/10	*	*	*	*	*	1.8×10^{-2}	
I 5	389.05	*	*	7.9×10^{-2}		<200/20	3.4×10^{1}	1.1×10^{1}	*	*	1.2×10^{-1}	*	
10		*	*	4.6×10^{1}		<200/10	*	*	*	*	*	2.5×10^{-2}	
J 2-1/2	388.91	*	*	2.1×10^{-2}		<200/25	*	9.5×10^{3}	*	1.3×10^{4}	*	*	
5		*	*	3.4×10^{2}		<200/10	7.1×10^{2}	6.7×10^{-2}	1.2×10^{1}	*	6.0×10^{-2}	*	
10		*	*	*		<200/10	*	*	*	*	*	*	
15		*	*	1.4×10^{2}	1.9×10^{1}	<200/10	*	*	*	*	*	*	2.0×10^{1}
K 5	389.8	*	5.0×10^{-1}	3.4×10^{-1}	1.6×10^{0}	<200/40	3.3×10^{0}	8.6×10^{-1}	9.2×10^{-1}	*	9.5×10^{-1}	2.5×10^{-2}	1.7×10^{-1}
15		*	*	*		<200/Bkg	*	*	*	*	8.1×10^{-2}	1.0×10^{-2}	
L 10	390.1	*	*	2.1×10^{2}	2.3×10^{0}	<200/10	2.4×10^{-1}	2.8×10^{0}	6.3×10^{2}	*	8.1×10^{-2}	*	1.6×10^{-1}
M 15	389	*	*	1.9×10^{2}		<200/Bkg	*	*	*	*	*	*	
N 2-1/2	389.83	*	*	2.4×10^{1}		<200/10	1.6×10^{-1}	6.8×10^{-2}	*	2.3×10^{4}	*	1.3×10^{2}	
7-1/2		*	*	2.1×10^{1}	6.9×10^{-1}	<200/10	4×10^{-1}	9.8×10^{2}	*	*	3.0×10^{-1}	8.2×10^{3}	2.4×10^{1}

*Below analytical detection limit Blank indicates not tested for or data unavailable
[a] - Isotope not decayed, no significant change due to large isotope half-life.
[b] - Elevation in feet above sea level for surface of borehole.
Source: Adapted from Dorian and Richards 1978 (decayed to January 1993).

Sample Locations Near 116-F-1 Lewis Canal



Source: Dorian and Richards 1978.

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Radionuclide Constituents in Subsurface Soil at the 116-F-14 Retention Basin (page 1 of 2)

Sample Number	Elev [a]	Depth	Material	^{238}Pu	$^{239/240}$Pu [a]	^{90}Sr	^{3}H	P-11 scaler	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U [a]	^{63}Ni [a]
		Concentration (pCi/g)														
AN		0 3.5	F S	* *	* 1.2x10^{-1}	5.6x10^{-2} 1.2x10^{1}	3.8x10^{1}		1.0x10^{0} 6.7x10^{2}	7.8x10^{-2} 1.6x10^{2}	2.3x10^{-1} 2.9x10^{2}	* 1.1x10^{-1}	1.6x10^{-1} 8.8x10^{1}	1.6x10^{-2} 1.8x10^{1}	6.9x10^{-1}	
BN		3 3.5	F S	* *	* 9.0x10^{-1}	2.3x10^{-1} 1.7x10^{-1}	9.6x10^{-1}		6.3x10^{-1} 2.3x10^{2}	7.2x10^{-2} 1.1x10^{1}	1.4x10^{-1} 6.6x10^{1}	1.3x10^{-4} 1.0x10^{-2}	5.4x10^{-2} 2.8x10^{0}	8.0x10^{-3} 3.7x10^{0}	2.6x10^{-1}	
CN		3 3.5	F S	* 9.6x10^{-1}	2.3x10^{-1} 4.5x10^{1}	5.4x10^{-2} 3.4x10^{1}			1.8x10^{-1} 3.9x10^{3}	3.1x10^{-2} 1.6x10^{2}	1.8x10^{-1} 1.4x10^{3}	* 8.9x10^{-1}	6.8x10^{-2} 3.9x10^{2}	1.5x10^{-2} 1.5x10^{2}	7.4x10^{-1}	
DN		3 3.5	F S	* *	* 1.2x10^{1}	3.3x10^{-2} 5.6x10^{1}	1.6x10^{0}		3.6x10^{-1} 2.7x10^{3}	2.1x10^{0} 1.6x10^{2}	6.0x10^{-2} 9.7x10^{4}	1.5x10^{-4} 4.3x10^{-1}	5.8x10^{-2} 1.1x10^{2}	6.5x10^{-3} 9.3x10^{1}	5.3x10^{-1}	3.4x10^{4}
AS		1 3.5 4	F S S	* 5.0x10^{-1} 3.4x10^{-1}	1.9x10^{-1} 1.7x10^{-1} 1.4x10^{1}	2.1x10^{-1} 7.3x10^{0} 2.8x10^{0}	5.7x10^{0}		1.0x10^{1} 3.2x10^{3} 2.4x10^{3}	1.3x10^{0} 6.4x10^{2} 4.8x10^{2}	1.9x10^{0} 1.3x10^{3} 2.6x10^{3}	* 1.8x10^{-1} 1.4x10^{0}	1.2x10^{0} 4.0x10^{3} 3.4x10^{2}	1.6x10^{-2} 8.0x10^{1} 2.6x10^{2}	1.1x10^{1}	3.3x10^{3}
CS		3.5 4	F S	* 5.9x10^{-1}	* 2.4x10^{1}	9.3x10^{-2} 6.6x10^{0}	1.4x10^{0}		1.2x10^{2} 5.9x10^{3}	5.1x10^{0} 2.7x10^{2}	3.1x10^{1} 1.8x10^{3}	1.1x10^{-3} 5.3x10^{-2}	3.5x10^{-1} 2.5x10^{1}	1.3x10^{-2} 7.0x10^{1}		*
DS		0 4	F S	* *	1.5x10^{-1} 1.5x10^{0}	1.9x10^{-1} 2.5x10^{0}	3.3x10^{0}		3.5x10^{1} 5.5x10^{2}	4.4x10^{0} 2.1x10^{1}	6.6x10^{-2} 1.4x10^{2}	1.3x10^{-4} *	2.4x10^{0} 1.4x10^{0}	4.8x10^{-2} 8.1x10^{0}	5.1x10^{-1}	
S	413.03	0 2 4 4.5 5 7.5 15	F F F F S N N	* * * * 5.4x10^{-1} * *	* * * 3.7x10^{-1} 1.9x10^{1} 9.5x10^{-1} *	7.3x10^{-2} 1.1x10^{-1} 1.1x10^{-1} 9.9x10^{1} 2.3x10^{1} 7.9x10^{-1} 2.5x10^{-1}	* 1.3x10^{0} 2.2x10^{0} 4.6x10^{0}	<200/50 <200/40 <200/40 1,000 15,000 800 <200/70	2.0x10^{1} 1.3x10^{1} 8.4x10^{0} 5.9x10^{1} 2.4x10^{3} 2.7x10^{2} 1.7x10^{0}	3.0x10^{0} 1.9x10^{0} 1.3x10^{0} 5.7x10^{0} 2.1x10^{2} 4.2x10^{1} 7.3x10^{0}	4.5x10^{0} 2.2x10^{0} 1.7x10^{0} 2.4x10^{1} 8.9x10^{2} 5.0x10^{1} *	1.2x10^{-3} 4.0x10^{-4} * 9.0x10^{-3} 5.3x10^{-1} 2.3x10^{-3} *	2.1x10^{0} 1.6x10^{0} 7.4x10^{0} 3.4x10^{0} 1.2x10^{2} 1.3.10^{1} 6.8x10^{0}	3.1x10^{-1} * * 3.9x10^{0} 8.4x10^{1} 1.0x10^{0} *	1.5x10^{-1} 9.6x10^{-2} 9.8x10^{-2} 3.5x10^{-1}	1.8x10^{3}
T	415.63	0 3 5 5.5 6 C1 8.5 20	F F F F S N N N	* * * * * * * *	* 3.1x10^{-1} * * 1.1x10^{0} 2.8x10^{0} 3.9x10^{-1} *	3.8x10^{-1} 1.1x10^{-1} 2.3x10^{-2} 7.3x10^{-2} 2.0x10^{0} 1.5x10^{0} 1.2x10^{-1} 7.3x10^{-2}	* * 2.6x10^{-1} 1.2x10^{0}	<200/40 <200 <200/30 <200/30 600 400 <200/100 <200/20	1.6x10^{1} 1.6x10^{1} 7.4x10^{0} 4.6x10^{0} 1.1x10^{2} 7.6x10^{1} 2.4x10^{1} 5.9x10^{-1}	1.8x10^{0} 1.2x10^{0} 9.0x10^{-1} 4.3x10^{-1} 1.2x10^{1} 3.2x10^{1} 1.3x10^{1} 3.5x10^{-1}	3.1x10^{0} 3.9x10^{0} 1.4x10^{0} 8.4x10^{-1} 3.1x10^{1} 1.8x10^{1} 5.2x10^{0} 1.0x10^{-1}	2.6x10^{0} * * 5.3x10^{-4} 7.3x10^{-3} * 1.8x10^{-3} 2.8x10^{-4}	2.8x10^{0} 1.3x10^{0} 1.7x10^{0} 1.0x10^{0} 7.4x10^{0} 5.9x10^{0} 1.0x10^{0} 7.4x10^{-1}	4.4x10^{-2} 4.9x10^{-2} * 5.3x10^{-1} 3.2x10^{0} 1.2x10^{0} 1.6x10^{-1} *	7.6x10^{-2} 5.5x10^{-2} 1.5x10^{-1} 1.5x10^{-1}	

Radionuclide Constituents in Subsurface Soil at the 116-F-14 Retention Basin (page 2 of 2)

Sample Number	Elev [b]	Concentration (pCi/g)														
		Depth	Material	^{238}Pu	$^{239/240}$Pu[a]	^{90}Sr	^{3}H	P-11	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U[a]	^{63}Ni[a]
U	414.10	0	F	*	*	*		<200/30	5.5×10^{0}	5.5×10^{0}	7.1×10^{-1}	1.0×10^{0}	2.8×10^{-4}	8.8×10^{-1}	2.0×10^{-2}	
		2	F	*	*	9.9×10^{-2}	*	<200	1.7×10^{0}	1.7×10^{0}	2.4×10^{-1}	4.5×10^{-1}	*	1.9×10^{-1}	*	1.2×10^{-1}
		4	F	*	*	3.2×10^{-1}		<200/Bkg	9.7×10^{-1}	9.7×10^{-1}	1.3×10^{-1}	7.1×10^{-2}	2.1×10^{-4}	1.5×10^{-1}	2.9×10^{-2}	
		4.5	F	*	3.2×10^{-1}	1.5×10^{-1}	*	<200/10	2.6×10^{0}	2.6×10^{0}	3.8×10^{-1}	7.6×10^{-1}	8.9×10^{-4}	2.9×10^{-1}	5.2×10^{-2}	8.5×10^{-2}
		5	S	*	3.1×10^{0}	8.6×10^{0}	1.4×10^{0}	800	1.3×10^{3}	1.3×10^{3}	8.3×10^{1}	3.1×10^{2}	*	2.7×10^{1}	1.9×10^{0}	7.7×10^{-1}
		7.5	N	*	1.7×10^{-1}	3.2×10^{-1}		/80	2.5×10^{0}	2.5×10^{0}	1.2×10^{0}	2.3×10^{-1}	*	1.2×10^{1}	*	
		10	N	*	3.0×10^{0}	1.8×10^{0}	6.1×10^{-1}	1,000	1.5×10^{2}	1.5×10^{2}	1.7×10^{1}	2.9×10^{1}	*	1.6×10^{1}	3.8×10^{-1}	4.2×10^{-1}
		15	N	*	*	7.9×10^{-1}		<200/20	3.4×10^{-1}	3.4×10^{-1}	2.2×10^{-2}	5.5×10^{-2}	*	1.5×10^{0}	*	

*Below analytical detection limit.
Blank indicates not tested for or data unavailable.
a - Isotope activity not decayed, no significant change has occured due to large isotope half-life.
b - Elevation in feet above sea level for surface of borehole
F - Fill.
S - Sludge.
N - Native soil beneath basin.
Source: Adapted from Dorian and Richards 1978 (decayed to January 1993).

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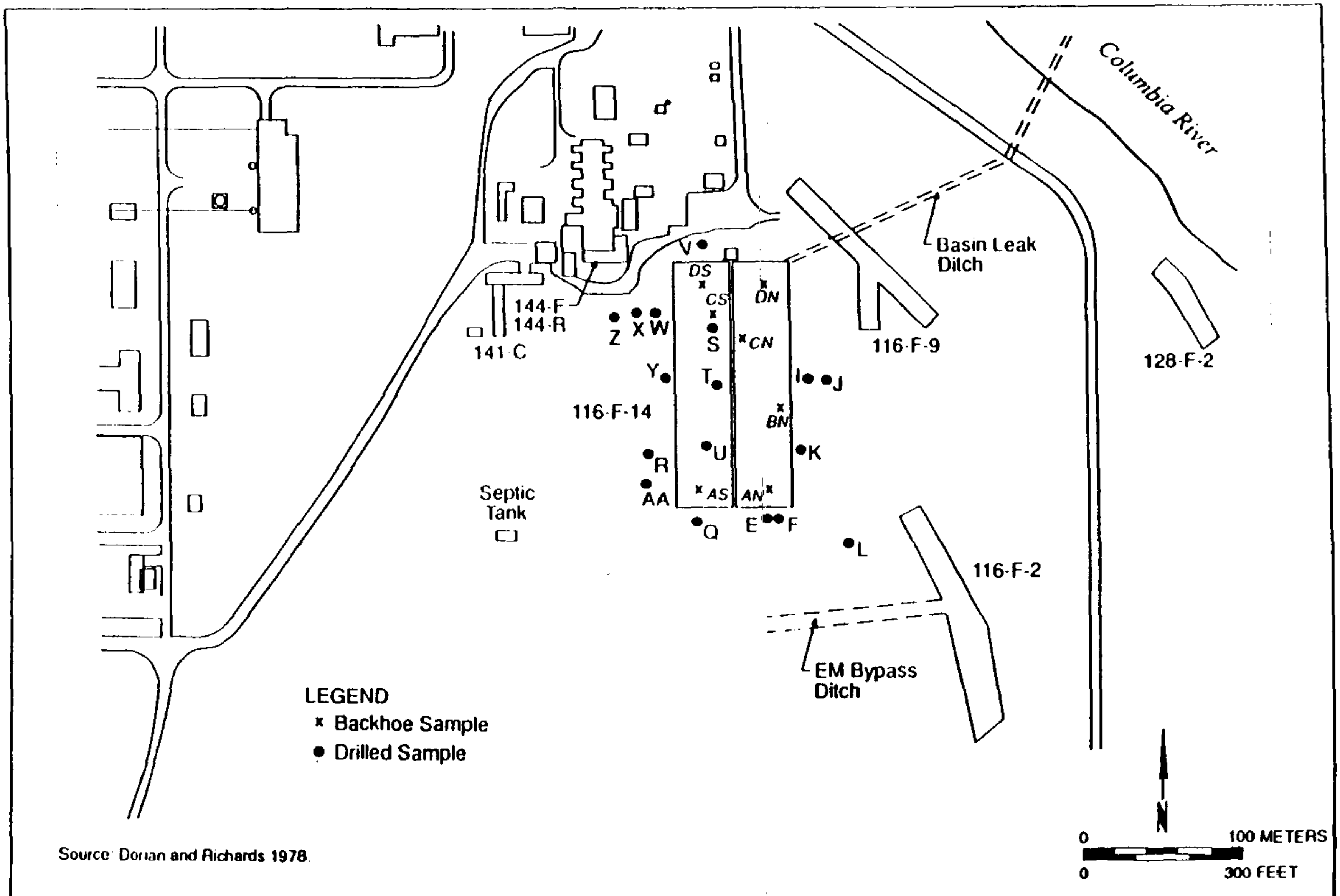
Radionuclide Constituents in Subsurface Soil at the 116-F-14 Retention Basin Perimeter Area

Sample	Number	Elev.[a]	Concentrations (pCi/g)												
			^{238}Pu	$^{239/240}Pu$[b]	^{90}Sr	^{3}H	P-11 Scaler c/m	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U[b]	^{14}C
E	5	412.55	*	1.2×10^{0}	5.8×10^{0}	2.2×10^{0}	3,000	3.1×10^{2}	5.2×10^{1}	7.6×10^{1}	*	3.5×10^{1}	3.1×10^{0}	3.9×10^{-1}	*
F	0	412.36	*	2.8×10^{-1}	6×10^{1}		1,000	2.6×10^{1}	1.1×10^{1}	6.6×10^{0}	*	2.3×10^{0}	9.2×10^{-2}	1.1×10^{1}	*
I	15	414.03	*	*	1.5×10^{1}		<200/20	6.3×10^{-2}	*	*	*	4.7×10^{-2}	3.5×10^{-2}		
	22-1/5		*	*	9.3×10^{1}		200	1.7×10^{1}	4.9×10^{0}	3.4×10^{0}	*	1.6×10^{0}	1.4×10^{-1}		
	25		*	2.1×10^{1}	3.2×10^{0}	1.2×10^{0}	700	7.1×10^{2}	1.1×10^{1}	1.6×10^{1}	*	1.8×10^{0}	5.0×10^{1}	1.2×10^{-1}	*
	30		4.5×10^{-3}	*	1.9×10^{0}		<200/20	5.5×10^{0}	3.4×10^{-1}	5.2×10^{1}	*	9.5×10^{1}	2.3×10^{-2}		
J	25	415.03	*	*	3.6×10^{0}	2.6×10^{1}	<200/80	3.9×10^{0}	3.1×10^{0}	7.8×10^{-1}	*	4.0×10^{0}	3.2×10^{-2}	1.4×10^{1}	*
	30		*	*	1.1×10^{0}		<200/40	5.9×10^{0}	2.4×10^{0}	1.0×10^{0}	*	3.0×10^{0}	4.1×10^{2}		
K	0	403.29	*	*	2.5×10^{1}	6.1×10^{1}	<200/60	1.1×10^{1}	1.6×10^{0}	2.0×10^{0}	*	8.1×10^{1}	6.6×10^{-2}	5.5×10^{-1}	*
	5		*	*	2.2×10^{1}		<200/10	1.1×10^{1}	3.5×10^{-2}	7.3×10^{2}	*	1.4×10^{1}	*		
	15		*	*	2.5×10^{1}		<200/10	2.0×10^{1}	*	*	*	1.5×10^{0}	2.0×10^{-2}		
L	0	411.52	*	4.7×10^{1}	8.6×10^{0}	2.4x10[illegible]	20,000	1.8×10^{3}	4.1×10^{1}	3.7×10^{2}	*	6.0×10^{1}	1.5×10^{1}	9.7×10^{-2}	*
	1/2		*	1.9×10^{0}	2.5×10^{1}		800	2.6×10^{3}	6.0×10^{1}	4.7×10^{2}	*	1.0×10^{2}	4.5×10^{1}		
O	0	404.7	*	*	1.1×10^{1}	7.7x10[illegible]	<200/25	1.5×10^{0}	1.2×10^{1}	1.4×10^{1}	2.2×10^{-4}	2.6×10^{1}	4.0×10^{-3}	4.6×10^{-2}	*
	10		*	*	1.6×10^{1}		<200/15	*	*	*	*	8.0×10^{1}	*		
	20		*	*	1.1×10^{-2}		<200/20	*	*	*	*	2.0×10^{0}	*		
R	0	412.39	*	*	9.3×10^{-2}		<200/15	2.7×10^{1}	3.1×10^{-2}	*	*	1.8×10^{1}	*		
	5		*	*	8.6×10^{-2}		<200/20	*	*	*	*	4.9×10^{-2}	*		
V	0	417.2	*	*	4.1×10^{1}	*	<200/20	2.9×10^{0}	1.8×10^{1}	3.9×10^{1}	1.8×10^{-4}	3.1×10^{1}	1.4×10^{-2}	3.0×10^{1}	*
	10		*	*	1.7×10^{1}		<200/10	*	*	*	*	*	*		
W	0	415.58	*	1.1×10^{0}	2.6×10^{0}		1,000	1.4×10^{2}	2.0×10^{1}	3.1×10^{1}	2.4×10^{-3}	4.8×10^{0}	1.4×10^{0}		
	12-1/2		*	2.1×10^{0}	2.0×10^{0}	4.2x10[illegible]	1,500	5.0×10^{2}	4.0×10^{1}	9.7×10^{1}	*	6.1×10^{0}	2.5×10^{0}	5.2×10^{1}	*
X	10	414.79	*	1.2×10^{0}	7.9×10^{1}	4.6x10[illegible]	800	2.6×10^{2}	6.4×10^{0}	3.7×10^{1}	*	6.8×10^{0}	4.7×10^{0}	3.5×10^{-1}	*
	20		*	1.4×10^{1}	4.4×10^{1}		<200/20	6.3×10^{1}	1.9×10^{-2}	8.9×10^{-2}	1.5×10^{-4}	2.9×10^{0}	*		
Y	25	427.09	*	3.8×10^{1}	1.4×10^{0}	*	<200/20	4.2×10^{0}	3.5×10^{-1}	7.1×10^{1}	*	3.0×10^{0}	5.6×10^{-2}	1.3×10^{1}	*
Z	10	414.43	*	*	*	1.6×10^{1}	<200	1.1×10^{1}	6.2×10^{3}	*	*	*	*	1.1×10^{1}	
	20		*	*	1.4×10^{1}		<200	7.6×10^{2}	7.7×10^{3}	*	2.5×10^{4}	1.2×10^{0}	*		
AA	5		*	2.1×10^{1}	1.3×10^{1}		<200	7.6×10^{-2}	1.2×10^{-2}	*	1.5×10^{-4}	1.2×10^{0}	1.1×10^{-2}		
	10		*	*	1.2×10^{1}	*	<200/15	6.3×10^{1}	7.2×10^{-2}	2.4×10^{1}	*	1.4×10^{1}	2.3×10^{-2}	1.9×10^{1}	
	15		*	*	1.9x10-1		<200	*	*	*	*	4.7×10^{1}	9.3×10^{-3}		

*Below analytical detection limit.
Blank indicates not tested for or data unavailable.
[a] - Elevation in feet above sea level for surface of borehole.
[b] - Isotope activity not decayed, no significant change has occured due to large isotope half-life.
Source: Dorian and Richards 1978 (decayed to January 1993).

Sample Locations for 116-F-14 Retention Basin



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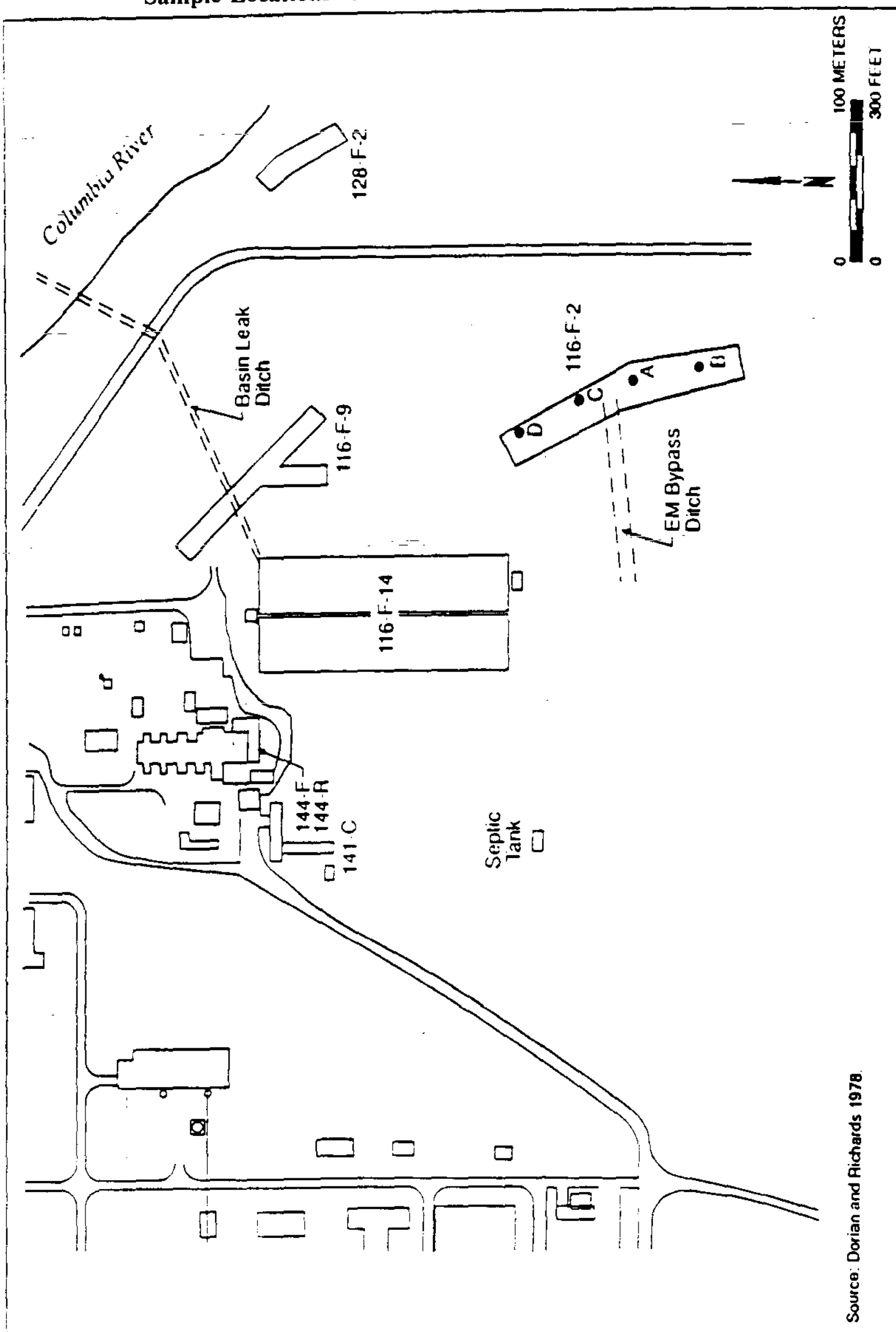
Radionuclide Constituents in Subsurface Soil at the 116-F-2 Basin Overflow Trench

Sample Location	Elev.^{a}	Depth (ft)	Concentration (pCi/g)											
			^{238}Pu	$^{239/240}Pu^b$	^{90}Sr	^{3}H	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U^b	^{14}C
A	408.15	10	•	•	5.2E-01		1.8E00	2.0E00	4.7E00	•	2.6E00	1.2E+00	8.8E-02	•
		18	•	•	2.8E 01		9.7E00	1.0E00	1.9E00	•	1.8E00	7.2E-02		
		20	•	•	1.2E 01		8.4E 01	8.0E-01	1.2E00	•	1.6E00	2.1E-01		
B	405.75	10	•	•	7.3E-03	•	6.3E-01	4.1E-02	3.4E-02	•	9.5E-02	2.1E-02	8.8E-02	•
		20	•	•	1.4E-01		4.2E-01	6.1E-02	2.1E-01	•	1.6E00	1.8E-02		
C	408.38	15	•	2.4E-01	8.6E 01		1.1E+02	7.8E00	1.9E+01	•	1.6E+01	2.8E00		
		20	•	3.4E 01	1.3E00	2.5E00	2.0E+02	8.8E00	4.2E+01	•	4.0E+01	2.4E00	1.9E-01	•
		25	•	3.6E-01	9.9E-01		7.1E+01	7.2E00	1.1E+01	•	5.8E00	4.7E-01		
		30	•	•	3.4E-01		1.8E00	2.8E-02	1.8E-01	•	6.4E-01	1.3E-02		
D	408.88	10	•	•	2.2E-01	5.4E00	5.9E+01	4.5E-01	5.8E+00	•	3.4E-01	1.5E-01	2.6E-01	•
		20			6.4E-02		4.6E-01	8.8E-03	7.6E-02		4.2E-02			

•Below analytical detection limit.
Blanks indicate not tested for or data unavailable.
^{a} - Elevation in feet above sea level for surface of borehole.
^{b} - Isotope activity no decayed, no significant change has occured due to large isotope half-life.
Source: Adapted from Dorian & Richards 1978 (decayed to January 1993).

Sample Locations for 116-F-2 Basin Overflow Trench



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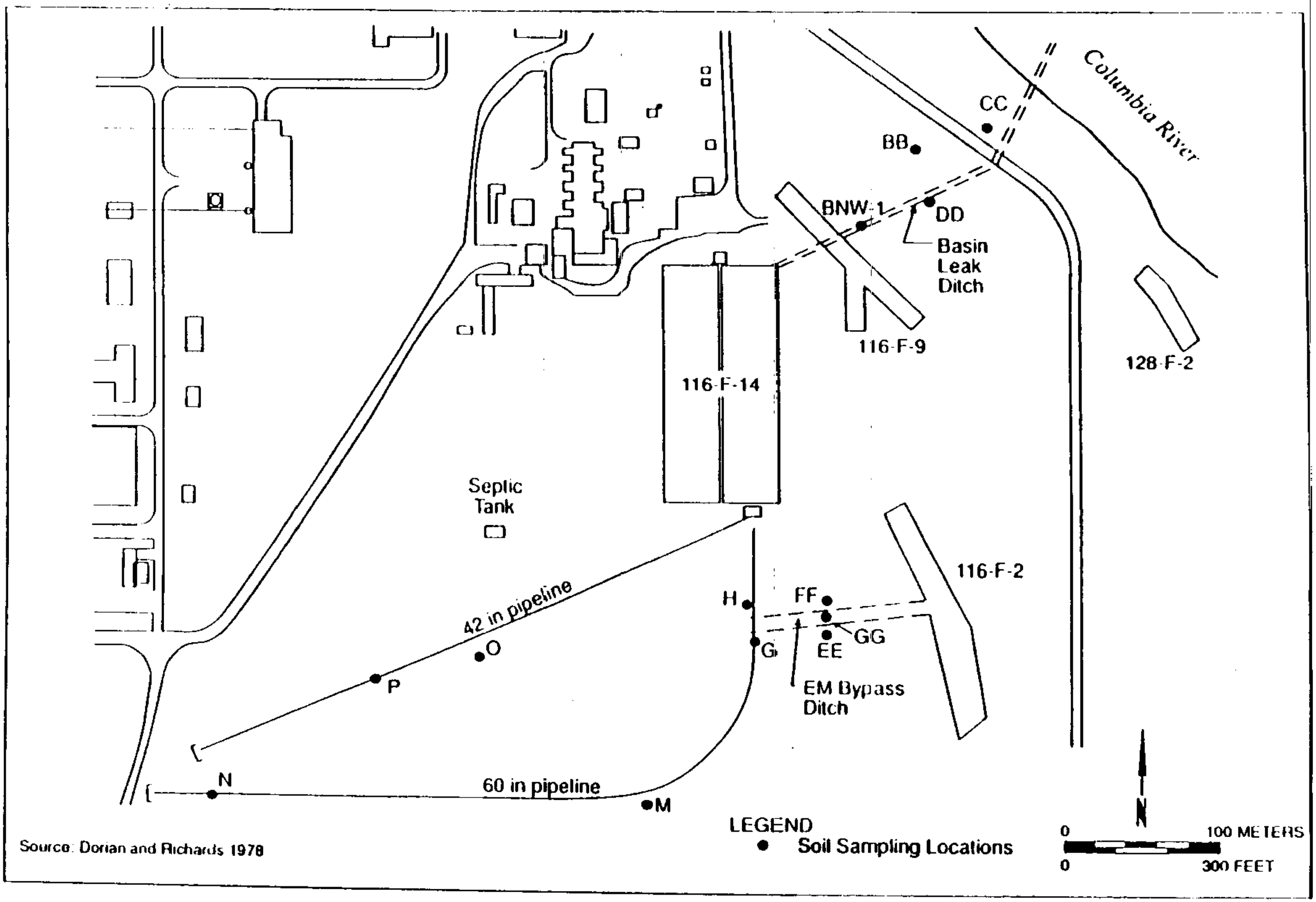
Radionuclide Constituents in Subsurface Soil in the EM Bypass Ditch and Basin Leak Ditch, and Near Pipelines

Sample Locations	Elev.*	Depth (ft)	Concentrations (pCi/g)												
			^{238}Pu	$^{239/240}Pu^{b}$	^{90}Sr	^{3}H	P-11 Scaler c/m	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U^{a}	^{14}C
EM Bypass Ditch															
EE	410.58	5	*	*	5.4×10^{2}		<200/15	*	4.5×10^{3}	*	1.1×10^{4}	2.0×10^{2}	2.0×10^{-2}		
		10	*	*	2.5×10^{1}		<200/10	8.4×10^{-2}	*	*	*	*	1.0×10^{-2}		
		20	*	*	2.4×10^{2}	3.8×10^{-1}	<200/30	1.8×10^{1}	1.7×10^{-2}	*	*	*	*	1.6×10^{-1}	
FF	410.09	5	*	*	*		<200/10	*	*	*	*	*	*		
		15	*	*	*		<200/10	*	*	*	*	*	*		
GG	410.03	5	*	*	1.7×10^{1}		<200/20	2.0×10^{0}	1.4×10^{-1}	3.7×10^{-1}	1.9×10^{4}	1.8×10^{0}	3.7×10^{-2}		
		7 1/2	*	*	9.3×10^{1}	3.3×10^{1}	200	2.3×10^{1}	6.1×10^{0}	9.7×10^{0}	7.3×10^{4}	3.3×10^{0}	4.2×10^{-1}	1.7×10^{-1}	
		10	*	*	1.1×10^{1}		<200/20	*	4.9×10^{-3}	*	*	*	1.0×10^{-2}		
G	408.61	8	•	5.5E-01	3.6×10^{0}		1,000	1.1×10^{2}	2.0×10^{1}	3.7×10^{1}	•	2.7×10^{1}	1.3×10^{0}		
		10	•	2.6E-01	1.7×10^{0}	2.0×10^{0}	1,000	1.5×10^{2}	5.5×10^{0}	3.4×10^{1}	•	1.8×10^{1}	2.5×10^{0}	1.4×10^{1}	•
		12.5	•	•	5.0×10^{1}		200	1.3×10^{1}	1.0×10^{0}	3.1×10^{0}	•	3.8×10^{0}	2.7×10^{-1}		
		15	•	•	3.5×10^{1}		<200/10	6.7×10^{1}	4.0×10^{2}	1.4×10^{1}	•	4.5×10^{1}	1.4×10^{-2}		
H	406.62	15	*	*	2.0×10^{1}	3.8×10^{1}	<200/40	8.8×10^{0}	6.8×10^{1}	1.5×10^{0}	*	1.4×10^{0}	2.5×10^{1}	5.7×10^{2}	*
		20	*	*	2.6×10^{1}		<200/20	4.6×10^{0}	9.2×10^{1}	7.3×10^{1}	*	6.2×10^{1}	1.5×10^{-1}		
Basin Leak Ditch															
CC	391.11	1	•	•	6.0×10^{1}		200	1.9×10^{1}	3.8×10^{0}	3.9×10^{0}	8.2×10^{4}	3.5×10^{0}	1.1×10^{1}		
		8.5	•	3.5×10^{1}	8.6×10^{1}	3.5×10^{1}	200	5.5×10^{1}	1.0×10^{1}	1.2×10^{1}	2.9×10^{3}	1.0×10^{1}	6.2×10^{1}	1.7×10^{-1}	•
		15	•	•	6.3×10^{2}		<200/10	•	7.5×10^{3}	•	•	•	•		
DD	392.01	5	•	•	1.7×10^{1}	2.1×10^{1}	<200/30	4.2×10^{0}	7.2×10^{1}	7.3×10^{1}	•	8.1×10^{1}	•	1.9×10^{-1}	
		12.5	•	•	7.3×10^{2}		<200/10	•	5.1×10^{3}	•	•	•	•		
BNW-1		2.5	•	6.1×10^{1}	2.5×10^{0}		1,000	1.3×10^{2}	2.6×10^{1}	2.3×10^{1}	6.9×10^{3}	2.8×10^{1}	1.8×10^{0}		
BB	391.34	15	•	•	2.7×10^{1}	2.9×10^{1}	<200/10	4.0×10^{1}	2.6×10^{2}	6.6×10^{-2}	1.2×10^{4}	1.8×10^{1}	3.0×10^{-2}	1.4×10^{1}	
Effluent Pipelines															
M	402.87	5	*	*	7.9×10^{2}	*	<200/10	7.1×10^{2}	*	*	*	*	*	1.2×10^{-1}	*
N	388.10	5	*	*	6.4×10^{2}		<200/20	*	*	*	*	*	*		*
O	406.18	5	*	*	1.5×10^{1}	*	<200/30	7.1×10^{-2}	7.8×10^{-3}	*	*	*	*	5.5×10^{-2}	*
		10	*	*	4.2×10^{2}		<200/10	*	5.0×10^{-3}	*	*	*	*		
		20	*		2.0×10^{2}		<200/10	*	*	*	*	1.8×10^{-2}	*		
P	403.07	5	*	*	1.7×10^{1}		<200/20	*	*	*	*	*	1.1×10^{-2}	3.8×10^{1}	*
		15	*	*	7.3×10^{-2}	4.2×10^{-1}	<200/20	*	*	*	*	2.4×10^{2}	*		
		20	*	*	1.3×10^{2}		<200	*	*	*	*	*	*		

*Below analytical detection limit.
Blank indicates not tested for or data unavailable.
* - Elevation in feet above sea level for surface of borehole.
ᵇIsotope activity not decayed, isotope half-life large enough no significant change in activity has occured
Source: Adapted from Dorian and Richards 1978 (decayed to January 1993).



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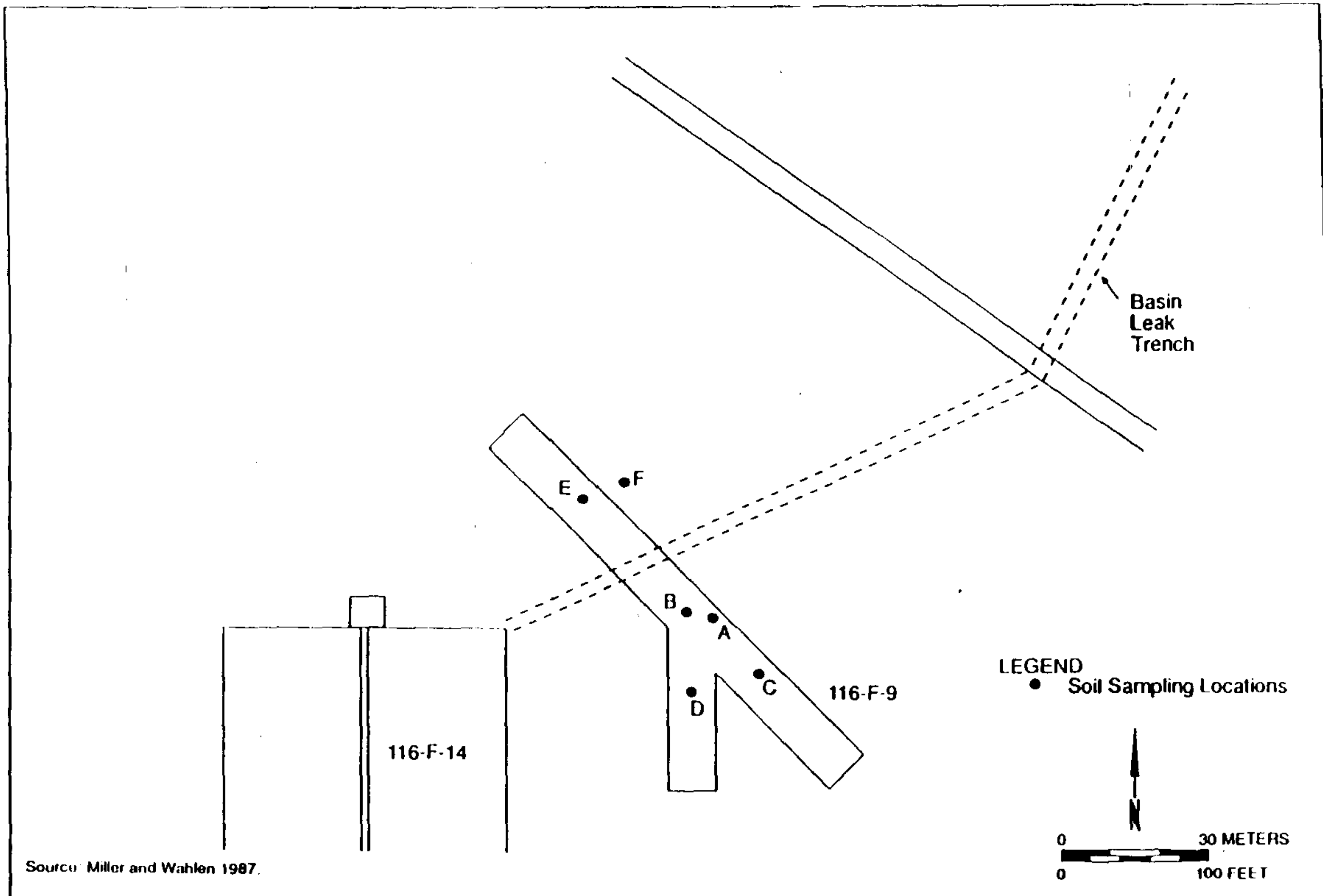
Sample Locations for Pipelines, the EM Bypass Ditch and the Basin Leak Ditch

9513333.0122

Radionuclide Constituents in Subsurface Soil in the 116-F-9 Animal Waste Leach Trench

Sample Location	Elev.[b]	Depth (ft)	Concentrations (pCi/g)							
			^{238}Pu	$^{239/240}$Pu[a]	^{90}Sr	^{152}Eu	^{60}Co	^{154}Eu	^{137}Cs	^{155}Eu
A	408.15	5	*			*	*	*	*	*
		10				*	*	*	*	*
		15	*	2.2E-01	7.3E+01	*	*	*	*	*
		17.5				2.3E-01	1.6E-01	*	5.3E-01	*
		20				3.3E00	1.3E00	*	2.0E00	*
		22.5	*	2.1E-01	6.2E+01	1.1E+01	2.9E00	1.8E00	1.9E00	8.0E-02
		25				1.3E+01	2.0E00	1.9E00	2.2E00	*
		27	*	5.5E-02	1.9E+01	1.0E00	1.6E-01	*	1.5E00	*
B	405.75	20	*	6.9E-02	3.2E+01	1.4E00	7.9E-01	*	7.4E-01	*
F	412.36	20				*	*	*	*	*
		25	*	*	3.4E00	*	*	*	*	*
		30	*	*	2.3E00	*	2.7E-02	*	*	*

*Below analytical detection limit
[a] - Isotope activity not decayed, isotope half-life large enough no significant change has occured.
[b] - Elevation in feet above sea level for surface of borehole.
Blank indicates not tested for.
Source: Adapted from Miller and Wahlen 1987 (decayed to January 1993).



Source: Miller and Wahlen 1987.

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Sample Locations for 116-F-9 Animal Waste Leach Trench

9513333.0123

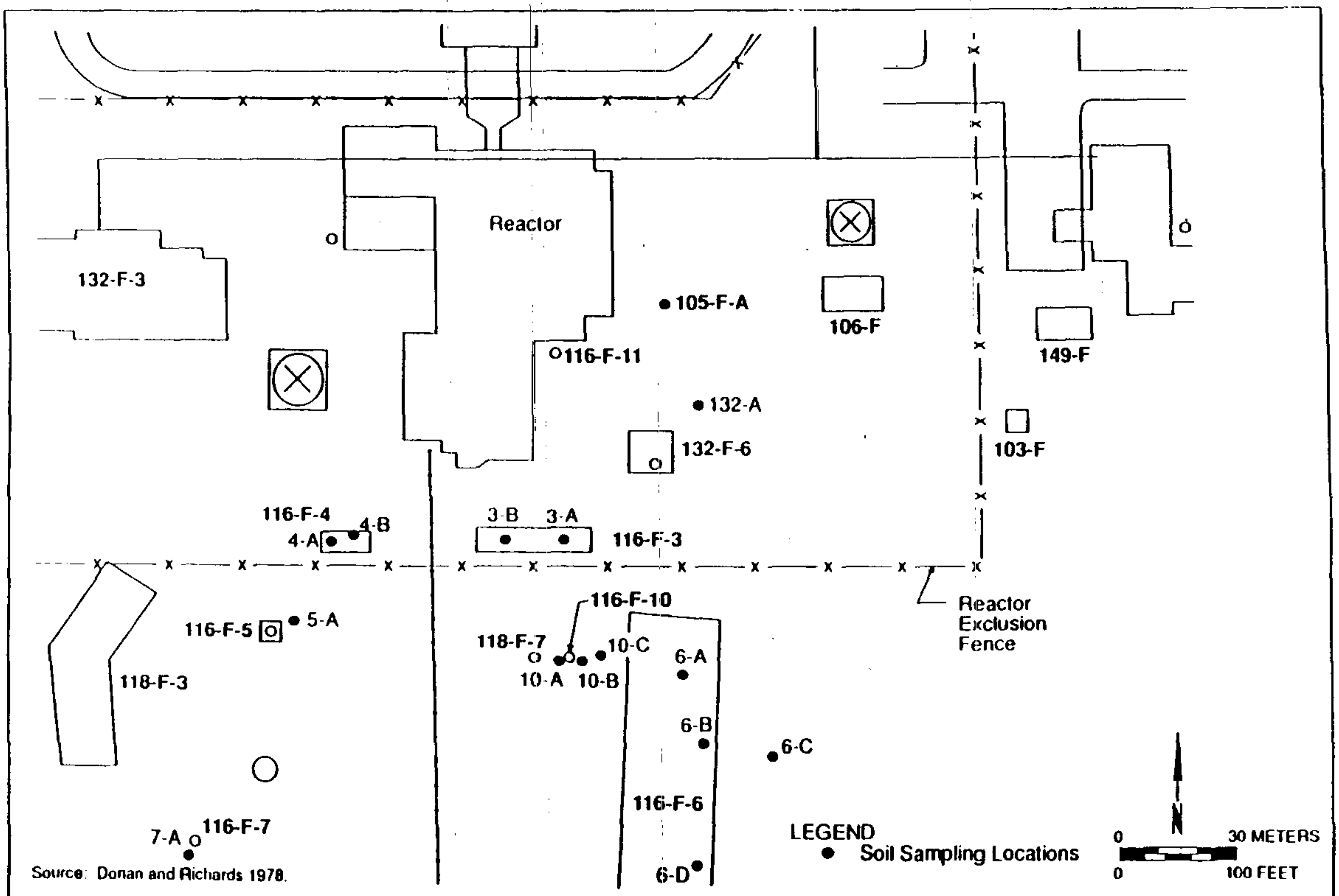
Radionuclide Constituents in Other Cribs and Trenches in the 100 F Area (page 1 of 2)

Sample Location	Elev.[b]	Depth (ft)	Concentrations (pCi/g)										
			^{238}Pu	$^{239/240}Pu^{a}$	^{90}Sr	^{3}H	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U^{a}
116-F-6 Liquid Waste Disposal Trench													
6-A	413.78	7-1/2	*	7.6E-01	6.5E00	2.6E+01	7.6E+01	1.5E+01	1.5E+01	*	4.9E+01	3.5E-01	1.9E-01
		15	*	2.0E-01	3.2E00		6.7E00	1.1E00	1.4E00	*	6.4E00	1.5E-02	
		27			3.0E00		8.8E-01	1.4E-01	1.7E-01	1.5E-04	7.4E-01	2.9E-02	
6-B	409.88	10	*	2.0E-01	2.0E00	2.1E+01	3.2E+01	4.7E00	5.8E00	1.3E-03	1.7E+01	4.7E-01	
		17-1/2	*	1.7E-01	2.3E00		2.0E+01	2.7E00	3.7E00	*	1.5E+01	6.7E-02	
		22-1/2			1.5E00		4.6E-01	3.6E-02	6.0E-02	1.7E-04	2.1E-01	6.8E-03	
6-C	414.48	25	*	*	1.5E00		*	*	*	*	*	1.0E-02	
		28			2.4E00		*	*	*	*	*	*	
6-D	409.9	5	*	*	1.5E00		3.2E00	3.5E-01	3.1E-01	1.8E-04	7.4E00	8.6E-03	
		20	*	5.7E-01	5.2E00	1.6E+01	5.5E+01	5.1E00	9.4E00	2.1E-03	2.3E+01	9.1E-01	1.5E-01
		25	*	*	7.3E00		1.6E-01	1.3E-02	5.2E-02	*	8.1E-02	*	
116-F-4 Pluto Crib													
4-A	410.2	8	1.3E00	1.1E+02	2.0E+03	5.4E00	8.6E00	*	3.4E+01	1.4E-01	3.7E+03	3.3E+01	1.3E00
		12-1/2	3.3E-01	2.9E+01	4.2E+02		5.9E00	1.5E-01	8.1E00	*	7.4E+02	2.4E00	
		20	*	7.2E-01	1.1E+01		2.4E-01	*	*	*	1.5E+01	2.9E-02	
4-B	411	5	*	1.1E-01	5.0E-02		*	*	*	*	4.0E-01	7.0E-03	

Radionuclide Constituents in Other Cribs and Trenches in the 100 F Area (page 2 of 2)

Sample Location	Elev.[b]	Depth (ft)	Concentrations (pCi/g)										
			^{239}Pu	$^{239/240}$Pu[a]	^{90}Sr	^{3}H	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U[a]
116-F-10 Perf Decontamination French Drain													
10-A	413.98	15	*	*	*		*	*	*	*	1.3E-02	*	
10-B	414	12-1/2	*	*	2.0E-01	7.3E+01	1.1E+02	4.1E+01	8.1E00	1.3E-03	1.2E+01	9.3E00	1.1E-01
		17-1/2	*	4.3E-01	1.1E-01		1.1E+02	6.5E+01	1.8E00	2.3E-01	5.0E+01	5.9E-02	
		27	*	8.7E-01	4.6E-01		4.6E00	4.3E00	1.2E00	1.6E-04	2.8E+01	2.1E-02	
10-C	414.2	20	*	*	*		1.4E-01	1.8E-02	*	*	*	1.9E-02	
116-F-3 Fuel Storage Basin Trench													
3-A	414.3	18	*	*	3.6E-02		*	*	*	*	*	*	
3-B	414	20	*	*	7.3E-02	5.4E-02	7.1E-02	5.3E-03	*	*	*	1.0E-02	
116-F-5 Ball Washer Crib													
5-A	409.23	10	*	*	1.8E-02		*	*	1.4E-01	*	2.7E-02	1.5E-02	*
116-F-7 Crib													
7-A	404.28	10	*	1.0E-01	3.8E-02		1.1E-01	*	*	*	2.2E-02	*	
116-F-11 Cushion Corridor French Drain													
105-F-A	413.1	5	*	*	2.3E-01	1.5E-01	2.4E00	9.4E-02	3.1E-01	*	1.0E00	1.0E-03	
132-F-6 Lift Station													
132-A		25	*	1.7E-01	1.3E00	1.2E+01	3.9E+01	1.3E00	5.0E00	1.3E-03	4.2E00	4.6E-01	
		30	*	*	5.4E-01		1.3E+01	4.4E-01	1.6E00	4.6E-04	1.1E00	1.4E-01	

*Below analytical detection limit.
[a] - Isotope activity not decayed, isotope half-life large enough no significant change occurs.
[b] - Elevation in feet above sea level for surface of borehole.
Blank indicates not tested for or data unavailable.
Note: Some data for sample locations C, D, and E were not available.
Source: Adapted from Dorian and Richards 1978 (decayed to January 1993).



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Sample Locations Near Cribs and Trenches

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